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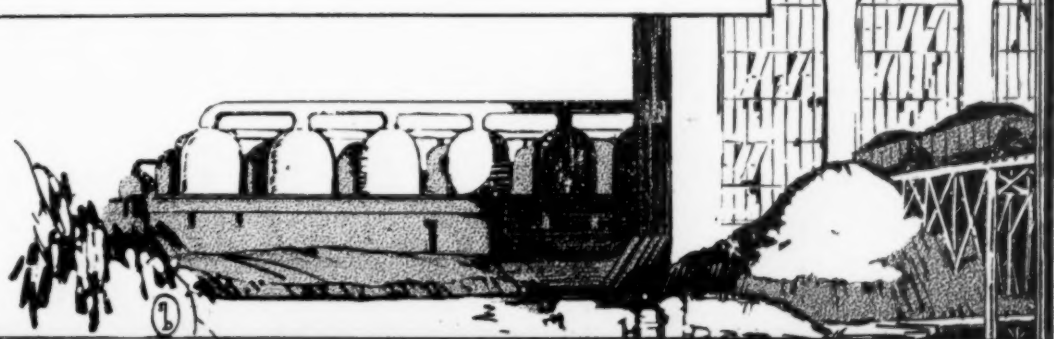
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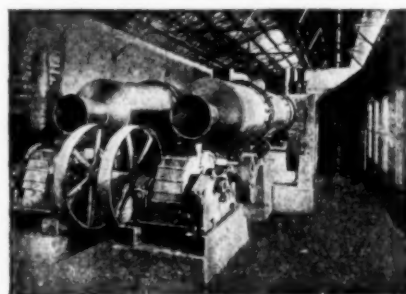
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Number 9

Colonel Fries Heads Chemical Warfare Service

ANNOUNCEMENT is made from Washington that Major-General WILLIAM L. SIBERT, who has been Director of the Chemical Warfare Service, has been relieved of his duties and ordered to Camp Gordon, Ga., to command the Fifth Division. Lieutenant-Colonel AMOS A. FRIES, who was in charge of Chemical Warfare Service overseas during the war, succeeds General SIBERT as Director. Both General SIBERT and Colonel FRIES have been active in support of the proposal to make the Chemical Warfare Service a separate branch of the Army instead of merging it with the Corps of Engineering. Their views have evidently prevailed, because the Army Reorganization Bill now before Congress recognizes the Chemical Warfare Service as a separate entity.

We regret the removal of General SIBERT from the Service, but welcome the appointment of Colonel FRIES as his successor. It is essential at this time to have an intelligent, sympathetic, enthusiastic officer at the head of the Service and Colonel FRIES embodies these qualities in quite as high a degree as did General SIBERT.

If our own wishes had been consulted, there would have been no change, but if it is impossible to have both of these officers in the organization, we are glad that one of them is still available.

Government Appropriation For the Forest Products Laboratory

AN APPROPRIATION has been requested from Congress by representatives of the wood-using industries for the support of the Forest Products Laboratory during the coming year. The Secretary of Agriculture has cut the original amount of \$500,000 to \$350,000, and the House Committee on Agriculture now further trims this sum.

The institution needs \$500,000. The many industrial concerns dependent on its researches demand it. Yet we find Congress, under the guise of saving money, planning to handicap one of the most serviceable of Government establishments. The honorable gentlemen are surely acting without a real knowledge of the functions and scope of activity of the Laboratory. CHEMICAL & METALLURGICAL ENGINEERING outlined the features of this work in the December 24, 1919, issue, and additional data are available in the Government files. The future development of the art is largely dependent on research work at Madison. The legislator who runs must read. There is often a mistaken idea of "the broader view." Economy becomes an obsession and the most worthy cause is ruined through the money-saving mania.

Chemistry, Metallurgy and The Bureau of Standards

APPROPRIATIONS requested for chemical investigations and service to allied industries by the United States Bureau of Standards, meager as they have been in the past, will be still further curtailed if the appropriation bill as submitted to the House of Representatives passes without amendment in the form of increases. Investigation discloses the fact that all appropriations for supplying standard samples of iron and steel, ores, materials for calorimetry and acidimetry have been cut off, and that the appropriation for determining the physical constants of materials is also eliminated. Furthermore, several of the best-paid chemical positions in the Bureau are about to be abolished.

The appropriation for the Bureau of Standards for the fiscal year ending June 30, 1920, is \$1,853,260. The requested appropriation for the fiscal year ending June 30, 1921, is \$2,986,440. The appropriation carried by the bill now in the House for the next fiscal year is \$1,217,360. We are hardly in accord with the idea of increasing at this time the annual appropriation for the Bureau by over one million dollars, but we are certain that last year's appropriation should not be scaled by over 30 per cent as proposed in the House bill.

Is Congress aware of the fact that preparation of standard samples was a money-making activity for the Bureau last year? In the recent report of the Director we note that the actual cash receipts from this work totaled more than \$6,000, while only \$5,000 was appropriated therefor. Even if this activity had not shown a cash profit, its service to the chemical and metallurgical industries is such that it should not be abandoned.

It is evident that if the industries want technical investigations by the Bureau to continue next year it will be necessary to lay the facts before the House Committee on Ways and Means. In all probability it will be found that the committee merely lacks the necessary information to enable it to appreciate the work which the Bureau is doing. Unless something is done to support this project, the work will be interrupted and the industries will be compelled to try to do for themselves individually those things which are natural functions of our national Bureau of Standards.

During the war no Federal bureau made more fundamental and important contributions to the national welfare than did the Bureau of Standards. Any organization which functioned as vitally as this Bureau at that time should not be handicapped in its normal development and operation, nor crippled in its peace-time industrial service.

Who Knows About Shale Oil?

OIL-SHALE promotion has passed the crest of the first wave. Two years ago, under the enthusiasm of a war-time need of rivers of gasoline to propel sub-chaser, tank, tractor, truck and airplane, many men convinced themselves and others that the failing supply from available crude could be quickly augmented from the stupendous reserves locked up in oil shale. So patriotic promoters immediately began their double campaign for oil production and thrifty investment with a vim, and made a deal of noise and collected not a few stray dollars, but, needless to say, produced no "gas" of a variety usable in internal combustion engines.

Since most of the stray pigeons were then plucked, it is now more popular to produce evidence of substantial effort toward the recovery of oil when selling stock certificates. Consequently not a few men have swelled the numbers of those already considering seriously ways and means to get oils, gases and fertilizers from shale. While a year ago it might fairly be said that the total production of oil from shale could be loaded on one truck, during the interval some experimental work on a semi-commercial scale has taken place in a few localities with a corresponding gain in knowledge, at least as to what kind of a plant should not be built.

Without desiring to add to the endless discussion as to whether the Scottish shale retorts should be adapted to American problems, whether byproduct coke ovens would be the proper point of departure, or whether some entirely new kind of muffle, roaster or calciner should be designed, it appears not unreasonable to believe that if a resourceful organization with proper financial backing should take more than a passing interest in the problem, a retort quite well suited to recover oil and gas from the particular shale to be treated could be soon devised. This is only a restatement of the opinion already voiced more than once in these columns that the successful utilization of shale will require a generous supply of competent technical and administrative talent.

At the present time, progress toward a solution of the problem is disappointingly slow, probably due to the fact that the resourceful organization has not yet become interested.

We have become accustomed to expect fruitful investigations of little-known natural resources from the Bureau of Mines, but this organization has badly diffused itself. The work begun at Salt Lake City has been halted; the Southern Pacific's retort plant at Elko, Nev., built under supervision of the Bureau's consultant, DAVID T. DAY, has not yet been fired up; a hopeful co-operative plant to be located in western Colorado has not yet materialized; and useful results from the work just initiated at Boulder, Col., cannot be expected for some time.

In the meantime, there is one big factor in the problem which has not been given the attention it deserves. It has been shown already that the oil produced on a small scale from various American shales has quite different characteristics from any of the crude petroleum now on the market. In fact, it is so different that grave doubts are entertained as to whether it can be sold in quantity to existing refineries. Such being the case, any organization intending large-scale production would be well advised to begin by purchasing a considerable quantity of shale oil from one of the plants

now operating, and institute a vigorous research at some well-equipped laboratory—such as the Mellon Institute—to determine its composition, its proper treatment, and commercial outlets for various easily procured fractions.

After all is said, the composition of the oil from a given shale bed is not going to be vitally changed by the small changes which are likely to develop in the retorting process—differing proportions in the fractions will be the greatest effect noticed. The Bureau of Mines' work may eventually be expected to give such data as the specific heat of the shale, its conductivity, and the effect of fine grinding, rate of heating and such factors on the yield of oil. These figures will all be available for use in the technical design of retorts, but the oil will still be a big problem after the retorting has been standardized.

It therefore seems to be a wise procedure to study the oil intensively, so that a plant with a sizable output of shale oil may not find itself with a white elephant on its hands.

Professor Haber And the Nobel Prize

THERE has been considerable criticism of the award of the Nobel prize in chemistry to Professor HABER, on account of his activities in chemical warfare in the German army. Before expressing a definite opinion we should like more facts than are available at this writing.

Inquiry from an American physical chemist of the first rank has brought the following reply:

So far as HABER's scientific deserts are concerned, his fellow-countryman NERNST is the only physical chemist in the world who hasn't the prize already who deserves it as much as HABER.

We may say right here that if NERNST had received it we should have been ready to express an opinion without hesitation. He belongs to the class of brilliant, able, original men who aided in giving to the German people their present burden of reputation. Another of the same type in the technical world is Professor DUISBERG, who visited America in 1912 and gave an illuminating performance of German offensiveness. Our correspondent continues:

NERNST was made a Count for his contributions to gas warfare, but their relative merits for the prize do not affect the issue. HABER is a brilliant, forceful, successful investigator who has worked in many branches of physical chemistry and has illuminated every one of them. I cannot recall another text book that has borne such rich fruit as his work on Thermodynamics of Technical Gas Reactions. His special work on the ammonia synthesis is but a single, isolated application of this broader study. He is a pioneer and leader in our science.

Personally I cannot say much at first hand about him, but what little I saw I liked . . . American and English students sought him out in large numbers, and they all liked him very much. Indeed I know of no other German chemist of the period, unless it was LUTHER or ABEGG, whom the Americans seemed to like so well.

So far as his activities in the war are concerned, I know nothing at first hand and have heard nothing authoritative about him. Some say he, others say NERNST, was the originator of gas warfare. It does not seem very likely that HABER began it, for he finished as a Captain. Most people who get in on the ground floor manage to do better.

If with the gas problem already decided upon by the General Staff and under way, the government ordered him to assist and direct such work, he isn't in a very different boat from many of us here. If he did originate

and advocate gas warfare, realizing its terrible potentialities, he deserves the contempt and execration of humanity. And he will get it.

It is hard enough to render judgment on a man even when you know that you know the facts; it is criminal to condemn him when you know that you don't know the facts. One precious heritage of our Anglo-Saxon past is the recognition that a man is innocent until he is proved guilty. Why throw this over when mercy—the safety of the weak—and justice are the very things we have been fighting to preserve?

This seems a fair presentation.

All Germans are not alike, although in war they seem so. A couple of years ago they were united in the most outrageous attack ever known upon the welfare of humanity, and we earnestly hope that they have been sufficiently beaten to know that they must never do so any more.

As individuals, however, they continue to live, and if any of their number deserves credit we should not withhold it from him.

Mr. Sulman's Contribution To the Study of Flotation

IT SHOULD be the unvarying custom of the scientist and the engineer carefully to scrutinize all technical or scientific matters coming before them, and apply to them the analytical methods of scientific research. It behooves the editor of a scientific and technical magazine also consistently to maintain this attitude of mind and practice in his own particular province, and to apply critical scrutiny to the technical papers which come to his notice.

Some months ago H. L. SULMAN presented a long paper before the Institution of Mining and Metallurgy, London, on "A Contribution to the Study of Flotation." The great length of the paper probably has prevented its widespread republication, despite the superficial evidence of its importance. The appearance in print on so elaborate a scale of an article on flotation by Mr. SULMAN after years of silence on his part and evident censorship by his employer, Minerals Separation, Ltd., has been a cause for comment. Elsewhere in this issue we publish an analysis of some of the facts relating to this belated contribution of Mr. SULMAN. One cannot help asking whether the paper now published contains the essential data which its author presumably had prepared for publication many years ago. His statements and those of his critics who discussed the article leave one in a confused state of mind as to the sincerity and reliability of the contribution.

In view of the disclosures by the U. S. Federal Trade Commission of the close commercial relations maintained during the war by Minerals Separation, Ltd., with Beer, Sondheimer & Co., we cannot help suggesting to our brother engineers in London that they should use all proper caution to see that their Institution is not prostituted to the service of corporate greed in the form of the late enemies of the British Empire and of all mankind.

In the interest of science and justice we believe that they should also use their influence to see that the original scientific treatise prepared jointly by Messrs. SULMAN and PICARD shall be published as originally written without the crossing of a "t" or the dotting of an "i."

The scientific world is entitled to this paper, the cause of justice demands its production, and Mr. PICARD is entitled to its publication in a form to which he is will-

ing to subscribe his name as co-author with Mr. SULMAN.

If purely scientific rather than business considerations have changed its authors' conceptions since this work was first written, proper footnotes could convince the public of their scientific disinterestedness.

The Wilson Dam At Muscle Shoals

AN ESSENTIAL part of the project to establish nitrogen fixation plants at Muscle Shoals was the construction of a dam and hydro-electric power plant at that point on the Tennessee River. Work on the project was authorized during the war, but it was soon found necessary to discontinue it for several reasons. In the first place, it was doubtful if the work could be completed before the war ended, and in the second place, it was a project of such magnitude as to require labor and materials which could not be diverted from other war needs. Now, however, the work is again under way, under the direction of the Engineers Corps of the Army, and a progress report is printed elsewhere in this issue.

With the controversies which have centered in this particular project we have no present concern. It is an undertaking which looks far into the future for its justification and we have little doubt as to the favorable judgment which will ultimately be pronounced. Certain it is that the project is located in a section of our country which has urgent need for the development of its industrial, agricultural and mineral resources, and in the long run we believe that the whole nation will profit. Political and sectional opposition and criticism against it may be expected from certain quarters, but in all probability it will be found of the same quality and inspiration which opposed the location of the nitrate plants at Muscle Shoals, but which promptly subsided when additional nitrate plants were "more favorably" located. The nitrate plants are at Muscle Shoals. They should be operated. The dam and power plant are essential to their operation, and the work should be completed at the earliest possible date.

Commercial Ambassadors In Mexico City

THE commercial conference called by the American Chamber of Commerce of Mexico in Mexico City last month was attended by representatives from many local civic bodies in the United States. President CARRANZA and other Mexican officials gave them a warm welcome.

Desire for trade begets peace in all civilizations. Mexico needs chemicals, pharmaceuticals, porcelain goods, paints, machinery of all kinds, textiles, bacteriological apparatus and other products necessary to constructive activities. In turn the United States desires in trade the tanning pod, fish oil, candelilla resin, vegetable wax, logwood, medical herbs, castor oil plant, lechuguilla fiber, vanilla beans, petroleum, etc. Mexico is a storehouse of wonderful raw materials for which the world should be her market.

This is something, then, larger than a deal in old jackknives. The meeting was a definite step toward peaceful relations and Mexican development, a summation much to be desired.

Western Chemical and Metallurgical Field

Manufacture of High-Grade Superphosphate at Anaconda

THE proximity of a potential source of relatively cheap sulphuric acid and large deposits of high-grade phosphate rock occurs in the Rocky Mountain northwest. Sulphide ores of copper, lead and zinc are treated in the metallurgical plants in this district in large quantities. These ores, or the concentrates obtained therefrom, are in most cases roasted as a preliminary metallurgical operation. Recent developments in the production of sulphuric acid from these roaster gases indicate the possibility of the manufacture of this acid in large quantities at a low cost. At present only sufficient acid is made to take care of local consumption, since the acid will not stand transportation charges for any great distances. The unused sulphur dioxide is expelled to the air. This is not desirable, as there are certain requirements that have to be met wherever smelters are located in agricultural communities and the smoke problem is one that smeltermen would like to solve economically if possible. The removal of sulphur dioxide from these gases would avoid certain objections to the discharge of these gases into the air. Large deposits of phosphate rock occur in Idaho, Utah and Wyoming from which the rock can be mined and transported to the smelters at a reasonable cost. The production of superphosphate from these materials is a simple matter and would create an outlet for sulphuric acid, but the ordinary grade superphosphate will not stand the freight rates to the market, which is largely in the Eastern states.

PROBLEM OF MARKETING DIFFICULT

The Anaconda Copper Mining Co. has given this subject a great deal of attention and has worked out a process for the production of a superphosphate that contains 48 to 50 per cent available P_2O_5 , or practically treble the percentage in the superphosphate that is ordinarily produced. This high-grade product will stand relatively high transportation costs, but the possibility of large-scale production depends upon the development of a market for this product. The marketing of this grade of superphosphate is not a simple proposition; in the first place, this material is too concentrated to be applied to the soil without mixing with inert material, and in the second place, the manufacturers of mixed fertilizers depend largely upon the inert material in ordinary phosphate to dilute high-grade nitrogen and potassium salts. The use of higher-grade fertilizers results in economy both in handling and in transportation and is desirable for both the consumer and producer. However, the education of the farmer along these lines has not as yet attained marked success. The use of larger amounts of phosphates is desirable especially in connection with the production of cereal crops; it is a characteristic of this element of plant food to bring these crops to maturity earlier and to increase the yield. Increased productivity of our agricultural lands is of national importance in view of the shortage of farm labor and the high wages demanded by experienced farm hands.

The Anaconda method of manufacturing superphosphate is to treat phosphate rock with sulphuric acid, producing a phosphoric acid, which is concentrated

and used in treating additional phosphate rock. The rock is crushed in a Blake crusher, dried on a Ruggles-Cole drier and ground to pass an 80-mesh screen in a Hardinge mill, which is in closed circuit with a Newago screen. This product is treated with 60 deg. Bé. acid in a series of three Dorr agitators and the pulp washed by decantation in a series of three Dorr thickeners. The pulp is filtered and washed on an Oliver filter. The filtrate is added to the last Dorr thickener; the overflow from the second Dorr thickener is added to the first Dorr agitator. The Oliver cake is wasted. The overflow from the first Dorr thickener will contain between 22 and 25 per cent phosphoric acid. This is concentrated in a coal-fired, direct heat evaporator to about 65 per cent H_3PO_4 . This concentrated acid is then mixed with ground phosphate rock in Pratt mixers, passed through a disintegrator, a Ruggles-Cole drier, ground in a Sturtevant "Ring-Roll" mill and discharged into a "den." This method of producing the superphosphate from ground phosphate rock and phosphoric acid is similar to the usual method using sulphuric acid. The product will, however, contain 45 to 50 per cent water-soluble phosphoric anhydride.

Operations at Ajo, Ariz.

The process being carried out at present at New Cornelia is the same as that originally recommended by Tobleman, and the results which have been obtained since the beginning of operation very closely check those he obtained in the experimental plants. There have been no material metallurgical or mechanical changes.

On Dec. 1, 1919, the leaching plant had operated 928 days, having leached during that time very nearly 4,000,000 tons of oxidized copper ore (3,600,000 metric tons), the total copper content of which averaged 1.52 per cent. Practically 72,000,000 lb. of electrolytic copper has been shipped and about 38,000,000 lb. of cement copper running approximately 60 per cent in copper (33,000,000 kg. and 17,000,000 kg. respectively).

The extraction obtained is somewhat over 80 per cent, while 0.7 lb. (0.32 kg.) of copper per gross kw.-hr. has been deposited in the tank house, this latter figure being but slightly less than was originally estimated. Likewise, the amount of discard necessary to prevent fouling of the solution has been very close to that originally reported, 90 gal. (340 l.) per min.

During the spring curtailment in production it was found that apparently the longer the time of leach and the lower the corresponding acid concentration, the less would be the amount of impurities which would be dissolved and consequently the greater the proportion of electrolytic copper to cement copper produced. This, of course, is a desirable condition.

Since nearly one-third of the oxidized ore has been consumed in the leaching process, a 500-ton experimental flotation plant has been constructed to determine the proper treatment for sulphide ores. This plant has been in operation since September, 1919. It is equipped with two rod mills, 42 in. x 9 ft. 8 in. and 60 in. x 10 ft., and a Hardinge mill, 8 ft. x 36 in. (1.07 m. x 2.95 m.; 1.54 m. x 3.05 m.; and 2.44 m. x 0.91 m. respectively); also Inspiration flotation cells and Deister tables. It is desired to determine the mills, flotation cells and tables best adapted to the ore, as well as the most efficient combination of oils. About 9,000 tons of ore had been milled up to Dec. 1.

British Chemical Industry

From our London Correspondent

London, February 1, 1920.

THE outstanding feature of the past month was undoubtedly the publication of the final report of the Nitrogen Products Committee on Jan. 15. Its appearance was the signal for vigorous criticism on all sides, particularly in regard to the delay in publication, the report having been in type since May, 1919. The 2,000-odd copies available for public as distinct from official distribution will probably be snapped up very quickly, and unless a second edition is printed it will be difficult for United States and foreign interests to obtain this valuable publication. It is understood that further details regarding physical data and the work of the Research Station, of which Dr. Harker is the Director, will be published shortly, and that the negotiations for the purchase by the Brunner-Mond interests of the Billingham Haber-type nitrate factory are practically completed.

CLAUDE PROCESS VIEWED WITH SCEPTICISM

The prospects of the Claude process recently acquired by Mr. Barton are viewed with some scepticism owing to the very high pressures involved. The statements made in the report regarding costs and manufacture of oxygen have been severely criticized and are said to be inaccurate. A proposal of the greatest interest is that of setting up standards of efficiency for large users of coal and for ammonia recovery based upon practice that has been uniformly realized under good working conditions. While a scheme of this kind would have been considered Utopian before the war, the suggestion is being treated seriously and in a national spirit of co-operation.

POLICY OF AMALGAMATION CONTINUES

The policy of amalgamation noted in my last article¹ has continued, the Castner-Kellner interests having been practically acquired by Brunner-Mond. Similar operations have been carried out in the steel, coal, glass and oil industries, and while it is realized that such collective action by the larger firms may be a national gain, public opinion still looks with suspicion upon the formation of powerful trusts with their latent drawbacks in regard to the creation of artificial prices and trade conditions. As regards the glass industry, it is interesting to note that the new factories will nearly all operate under the Owens patents—an American invention.

CHEMICAL TRADE ACTIVE—SUPPLIES SHORT

The chemical trade remains very active, with acute shortage of supplies, many firms being sold out to the end of the year. Soda ash, caustic soda and many other commodities are almost unobtainable. The rubber position is very interesting, prices showing an upward tendency on account of the fall in the American exchange and the rise in the price of silver, wages being chiefly paid in the latter commodity.

The Association of British Chemical Manufacturers has just published a directory of its members printed in seven languages, and assures purchasers that goods ordered by them are actually produced by the firm in question. While this statement is quite *bona fide*, it often happens just now that manufacturers list many

more products than they are actually manufacturing at the time, and "borrowing" or importation is often necessary to make up the deficiency.

TRADE UNION MOVEMENT SPREADING AMONG CHEMISTS

As regards chemical merchants, signs are not wanting that these interests also will join forces in a more powerful association than that now existing, and the chemical trade dinner on Feb. 12 will no doubt prove an excellent lubricant. The trade union movement is now spreading its net to include even such chemists as belong to the National Association of Industrial Chemists, the British Association of Chemists, etc., the proposal being to join forces with similar "professional" interests, such as those of the engineering draftsmen, bank and insurance clerks, etc.

UNIVERSITIES NEED FUNDS

At the universities, the claim of the Imperial College of Science to grant its own degrees is causing much heartburning, while the lead of Manchester University is likely to be the forerunner of many other appeals for additional funds to cope with the ever-increasing influx of students.

FUEL SITUATION CAUSES WORRY

The fuel situation is attracting further attention, in view of the impending shortage of petrol due to the presumed increased American requirements. It is predicted that two years hence the United States will have no petrol to spare for export and that this country must resort mainly to benzol, alcohol and motor spirit derived from the distillation of coal, if the cost of motor fuel is to be kept within reasonable limits. The work done by Ernest Bury at the Skinningrove Co.'s works on the manufacture of alcohol from ethylene and the simultaneous appointment of Sir Frederic Nathan as power-alcohol investigation officer under the Fuel Research Board give some indication of the present trend of opinion, while in engineering circles much attention is being given to the possibilities of producer-gas units for vehicles propelled by internal combustion engines.

CO-OPERATION WITH U. S. DESIRABLE

The announcement that American chemical and physical societies are to create a fund for the verification and publication of physical data and constants should lead to co-operation with the Chemical Engineering Group of the Society of Chemical Industry, which is also to devote time and effort to this essential work.

Value of Last Year's Exports From United Kingdom to United States

The declared value of the exports from the United Kingdom to the United States in 1919 aggregated \$359,671,231, exclusive of the Birmingham consular district and West Hartlepool agency, from which returns have not been received. The total in 1918 for the whole of the United Kingdom was \$143,272,830. The following increased values in 1919 are noted by consular districts: London, \$144,000,000; Liverpool, \$18,500,000; Bradford, \$17,000,000; Manchester, \$12,000,000; Dundee, \$11,000,000; Nottingham, \$5,500,000; Glasgow, \$4,000,000. American vessels of 1,003,258 gross tons entered the port of London in 1919, against 134,823 tons in 1918, as shown by the records of the consulate general.

¹See CHEM. & MET. ENG., Feb. 4, 1920, p. 200.

Senate Debate on Dye Bill

LIVELY debate was aroused in the Senate on Feb. 25, by the introduction on the Senate floor of the dye bill. That there will be opposition to the measure was indicated by the attitude of various Republicans and Democrats. The Republican objections are based on the fact that the bill is a departure from the usual form of protective legislation. Senator Kenyon of Iowa characterized it as "a very unusual bill and a rather strange application of the protective tariff theory." Senator Thomas of Colorado, a Democrat, assured the Senate that he would speak at length in opposition to the bill. After four hours of debate the bill was temporarily set aside to make way for the Peace Treaty discussion. No definite predictions can be made as to when the bill will be taken up anew.

Senator Kenyon opposed any haste in considering the bill, as he was avowedly suspicious at finding so many of the Democrats supporting what he termed a high-tariff measure. Senator Simmons, the ranking Democrat on the Finance Committee, explained, however, that the tariff rates had been reduced by the Senate to the rates in the present law which was passed by a Democratic Congress. Senator Kenyon called attention to the fact that there were other things in the bill besides rates and Senator Watson admitted that the bill is and was intended to be an embargo measure.

MAGNESITE AND CHEMICAL GLASSWARE BILLS READY BUT HELD BACK

Senator Poindexter of Washington objected to the failure of the Finance Committee to report out, as well, the magnesite and other emergency tariff bills. This led to the revelation that the Finance Committee had decided to report favorably to the Senate the magnesite bill and chemical glassware bill, but that at the last minute the committee decided to withhold the report on these bills for the present. The reason for this unusual action, it was stated by Senator Smoot, had best not be revealed at this time.

Senator Poindexter was prompted by this admission to declare that "the fact that the report which has been ordered was suspended indicates that very likely some influence—probably that which is interested in Austrian mines—is endeavoring to prevent any report at all on magnesite." He insisted that before the dye bill was presented to the Senate for a vote the magnesite bill must be on the calendar.

SMOOT FOR STRAIGHT PROTECTIVE TARIFF

Senator Smoot expressed his view of the dyestuffs legislation as follows: "If I had had my way about it, the dye measure would have been a straight protective bill, providing a specific duty that would protect the dye industry of this country. I would not have put an embargo provision on it or any license system as provided in the House bill. I believe in a protective tariff principle. I would have granted a reasonable rate of protection in this bill. I would not shy at a protective duty particularly if it were limited to three years, as in this bill the embargo provision is limited, to take care of special items. This bill is limited to three years and no industry within that time could be established and begin the manufacture, say, of vat dyes required by a large majority of the cotton manufacturers of the country."

At another point in his argument Senator Smoot made the following significant statement: "I will say frankly

that if I had my way about it we would have an entire revision of the tariff, but whenever the tariff is revised, whether it be up or whether it be down, the business interests of this country are unsettled. What is the use of unsettling the business of the country when we know that a protective tariff bill would not be signed at the other end of the avenue?"

Senator Watson called the attention of the Senate to the fact that the favorable report made by the subcommittee on the dye bill was unanimous and that the report made by the full committee to the Senate also was unanimous.

KNOX SUPPORTS DYE BILL

Speaking in support of the measure, Senator Knox of Pennsylvania said in part:

"The forces that held the legions of civilization at bay and almost overcame them were the spectacled chemists of Germany. The whole face of the world has been changed by the creative or synthetic chemist within the last ten or fifteen years.

"If this measure was a project to invest a billion dollars of Government money for the purpose of building up an industry that would save a billion dollars a year and be a great factor in our preparedness against another destructive war I would favor it, but it is not that. The gentlemen who proposed to build up these industries will do it at their own expense, and all that they ask the Government of the United States to do is to prevent for a period of three years the importation into this country of such dyes as are made here in merchantable quantities. The proposition is reasonable. It has nothing to do with the tariff. It is not a question of tariff legislation. It is a question of wise, far-seeing preparedness, and of wise, far-seeing economy."

Plans of Dye Section, A. C. S.

The second meeting of the Dye Section, American Chemical Society, will be held in St. Louis, beginning Wednesday, April 14. At this meeting the committee on permanent organization will submit bylaws for the consideration of the Section, the approval of which, by the Section and by the Council, will be the necessary steps to the permanent organization of the dye chemists of the United States, as the Dye Division of the American Chemical Society.

The secretary asks all scientific workers in the field of dyes to present the results of their researches and experiences at these meetings of the dye chemists. Papers on the manufacture, properties or application of dyes, both of coal-tar or natural origin, will be of timely interest. Any chemist having any such scientific information ready for presentation is asked to communicate at once with the secretary, giving subject and time for presentation.

As is usual, full details of the final program, time and place of meeting can be obtained by addressing Dr. C. L. Parsons, 1709 G Street, N. W., Washington, D. C., or Dr. R. Norris Shreve, secretary, 43 Fifth Ave., New York City.

Colloquium on Electrochemical Research

Electrochemists of New York City who would like to organize a fortnightly colloquium on current researches are asked to communicate with Prof. H. C. Cooper, College of the City of New York. The organization will be informal, voluntary and mutual. Several experienced men are expecting to attend.

Iron and Steel at the A.I.M.E.

A Summary of the Discussions and Papers Read at the Winter Meeting — Blast-Furnace Flue Dust, Malleable Iron, Alloy Steel, Boiler Plate, Gun Construction and Theoretical Metallurgy Were All Treated in a Most Interesting Manner

VERY interesting sessions devoted to iron and steel metallurgy were held both morning and afternoon of the closing day of the winter meeting of the American Institute of Mining and Metallurgical Engineers held Feb. 16-19 in New York City.

A synopsis of the papers read and commented upon by members present will be given below.

Flue Dust

A discussion of the causes of blast-furnace flue dust and a new furnace-top design to prevent its production was given in a paper by R. W. H. ATCHERSON. Blast-furnace dust is troublesome at best, but the amount produced seemed to have little connection to the fineness or origin of ore charged; rather a close attention to innumerable details of furnace and accessory construction and operation has enabled the industry to reduce materially the amount of dusting in the face of finer and finer ores. Since the charge must evidently act as a filter, as uniform a mixture as possible should be placed in the furnace, to prevent almost explosive rushes of blast, breaking through a finely packed stratum. In addition, ample areas of furnace dome, out-takes and downcomers are essential. Mr. Atcherson thought that the superiority of turbo-blowers was not so much on account of the lack of pulsations (which were effectually dampened before arrival at the tuyere) as of the excellent governors capable of keeping volume and pressure uniform in the face of wide variations in steam pressure—something which governors attached to reciprocating engines could not possibly do. The author's design calls for six gas-regulating goosenecks connected to two large downcomers, the entire system intended to reduce and equalize velocity, and control its pressure—all most important factors in dust production. As to the handling of the recovered dust, he observed that wet sludge is much easier and safer to handle than hot dust, and if his idea was correct, that the content of fine coke was the root of rehandling difficulties, and therefore that wet flue dust free from coke should not disturb any function of the furnace, it was proper to experiment along the line of effecting a wet separation of these two ingredients, rather than to use the coke as a fuel for sintering, a practice which results in material most difficult to smelt because of its content of iron silicel!"

SINTERED VS. RAW DUST

C. A. MEISSNER, in discussion, said that in general it slows down iron production to charge raw dust, although the lines of the furnace have a large influence on the amount of flue dust produced, or the capacity to smelt it when recharged. The speaker, however, was not ready to acknowledge that either turbo-compressor or blowing engine had a decisive advantage. In spite of the formation of silicates, Mr. Meissner thought that well-sintered dust was preferable for charging, espe-

cially in case fine coke could not be first separated if the raw dust was returned, since the finest coke tended to go through the furnace unconsumed, and entering the slag, make it extremely infusible.

Semi-Steel for Shells

"Manufacture of Semi-Steel for Shells" was described by F. E. HALL. Limiting the term to cupola metal resulting when ample steel scrap is charged, he described the chemical and physical requirements of good semi-steel. Cupola practice must be most carefully controlled if uniform results are to be attained, and the author notes many precautions to be observed.

HENRY D. HIBBARD called attention to the fact that "semi-steel" was a much abused term, and while it was not ideal for cupola metal described by Mr. Hall, it seemed to be so well established that it would be desirable to retain, exclusively if possible. At present "semi-steel" might also be applied to the low-carbon product of an air-furnace, to malleable iron castings, to cast iron synthesized from steel turnings, or, according to at least two modern unabridged dictionaries, to "puddled steel"!

USE FOR RESISTANCE TO ABRASION

Attention was called to the exceptional wearing qualities of some semi-steels by R. F. HARRINGTON, who thought that real information was needed as to whether cupola or air-furnace semi-steel was superior for abrasion-resistant parts such as locomotive cross-head shoes. Mechanics generally prefer cupola semi-steel, even if physical tests appear quite similar. For determining this essentially practical point, a good testing machine should be designed. THOMAS GILMORE observed that iron for molds varied enormously in durability, and when he could get a foundryman to make him a "white iron," with the proper amount of steel in the charge and cast to have a very fine grain, the wear obtainable would compare favorably with the best manganese steel. H. A. HIXON confirmed this statement as to the wearing qualities of crusher jaws and roll shells. If these are cast against chills, with soft iron strips in the back of the casting, they would outlive the best manganese steel pieces he had ever seen.

One-Piece Gun Construction

"An Experiment in One-Piece Gun Construction" was described by P. W. BRIDGMAN. He noted that when firing a gun the interior parts of the tube are stressed at a much higher rate than the outer portions, with the result that the intensity of stress varies considerably inside to outside. For safe strength, then, considerable weight of metal is always present, which does not work to very high efficiency. By the ordinary method of keeping the interior of the gun from being strained beyond the elastic limit, thus acquiring a permanent set to the utter destruction of its accuracy, it is usual to shrink

the jackets over the tube, thus initially compressing those portions which eventually withstand the highest tension. Another scheme which was tried under his direction was subjecting a one-piece forging to heavy internal hydrostatic pressure, causing the entire tube to flow and acquire a permanent set, and at the same time a much elevated elastic limit. After such a treatment, the bore could be rifled and the barrel was ready for mounting. Practically, the chief difficulty was to devise packing tight against such excessively high pressure (100,000 lb. per sq.in.) but this problem was solved in a satisfactory manner, as described in the paper. A 3-in. gun was made in this manner, which withstood successfully extra-vigorous testing, and the scheme was being elaborated for large-scale application when hostilities ended. It would reduce the number of operations necessary in manufacture, with a corresponding reduction in time and expense, and the method of fabrication would submit the tube to far greater stresses than it would ever receive in service.

ITALIAN GUN MANUFACTURE

It developed in the discussion that the French were using a similar scheme in making a composite barrel. The tube was expanded into the jacket by internal pressure, rather than the jacket shrunk on by heat. Dr. F. GIOLITTI also said that Ansaldo Co. in Italy had made very many guns during the last years of the war on exactly the same principle as described by Dr. Bridgman, in size up to 10 in. Their two difficulties were to produce the high pressure required with rather meager apparatus, and to so arrange the equipment that different pressures would be exerted at different parts in the tube, as required by their working resistances. He described a fixture which was devised to accomplish this, consisting of a bar slightly less in diameter than the gun bore. This was inserted into the tube, and the annular space packed at the limits of the area desired to compress, then hydrostatic pressure introduced by means of small openings through the bar.

Tensile Strength of Boiler Plate

H. J. FRENCH studied the "Tensile Properties of Boiler Plate at Elevated Temperatures" at the Bureau of Standards. A short rectangular test bar was gripped in a tension machine by special long jaws, and then a tubular electric furnace placed around it. When the test bar had reached a desired stationary temperature, a stress-strain curve was obtained by means of compensated extensometers affixed to the jaws by a wide yoke spanning the electric furnace. His results were tabulated and presented as graphs, and exhibit the fortunate fact that the tensile strength and elastic limit either are maintained or are actually increased up to about 200 deg. C., a fact important in the use of such materials for high-pressure steam boilers. A more detailed summary of his results follows:

"In both grades of plates (firebox and marine) increase in temperature from 70 to 870 deg. F. (21 to 466 deg. C.) is accompanied by distinct changes in strength and ductility, viz.: (a) The tensile strength at first decreases a few thousand lb. per sq.in., reaching a minimum at about 200 deg. F. (93 deg. C.). This is followed by an increase up to about 550 deg. F. (288 deg. C.), where the tensile strength reaches a maximum about 10 per cent greater than the normal room tem-

perature value, after which another and final decrease occurs. (b) The percentage elongation in 2 in. (5 cm.) decreases rather slowly up to about 200 deg. F. (93 deg. C.), after which it drops more rapidly, until a minimum is reached at about 470 deg. F. (243 deg. C.). This factor then increases throughout the balance of the range under consideration. (c) The reduction in area closely follows the inflections registered in the curve for elongation but has a minimum at slightly higher temperature than the elongation. (d) The proportional limit at first increases slightly and shows a maximum in the neighborhood of 400 deg. F. (204 deg. C.) for the firebox plate and the highest values between 200 and 300 deg. F. (93 and 149 deg. C.) for the marine plate. It is noted that both the actual and the percentage increases are much greater in the case of the firebox grade and that the subsequent and final decrease in proportional limit for this plate takes place more sharply than in the case of the marine grade of boiler plate.

"In the case of the firebox plate, the proportional limit is maintained above its original average room temperature value of 23,300 lb. per sq.in. to a higher temperature than is the case with the marine plate. It is probable that this may be associated with the greater mechanical work received by the firebox plate."

Graphitization of White Cast Iron

In a closely written paper on the above subject, R. S. ARCHER reaches the main conclusions that from the available evidence A₁ for a 1.0 per cent silicon iron is probably within 15 deg. of 750 deg. C. Annealing experiments on a typical hard iron showed that the combined carbon may be reduced to 0.05 by 168 hr. at 690 deg. C., or 135 hr. at 735 deg. C., both undoubtedly below A₁. However, annealing at 785 deg. C. showed 0.5 per cent graphite after 10 hr., 0.12 per cent after 11 hr. at 735 and but 0.06 per cent after 24 hr. at 690 deg. C. Further evidence as to the temperature ranges of graphitization is furnished by reheating completely graphitized iron, re-establishing the well-supported facts that there is no re-absorption at 749 deg. C., but a considerable reversion to combined carbon at 771 deg. C.

"It therefore appears to be a well-established fact that there is a temperature above which the graphite of a completely graphitized iron will go back into solution, to be reprecipitated on cooling as iron carbide. For iron of the composition used for malleable castings (0.5 to 1.0 per cent silicon) this temperature is approximately 765 deg. C. The conclusion seems inevitable that combined carbon cannot be completely converted to graphitic carbon under conditions that cause graphitic carbon previously formed to revert to dissolved carbon and, on moderately rapid cooling, to cementite. That is, it is not possible above this critical temperature to completely convert combined carbon to graphitic carbon. If this is true, it follows that the complete conversion regularly obtained in proper annealed malleable castings must, of necessity, take place in its final stages either at or below this critical temperature.

"Whether the completion of graphitization takes place at or below a definite critical temperature is a question of importance. If, as maintained by some writers, the complete conversion to graphite takes place at this critical temperature and not below it,

such conversion must consist in the direct precipitation of an iron-graphite eutectoid. For if the conversion took place simultaneously with the formation of pearlite, there is no reason to suppose that it would not continue at temperatures slightly below the critical."

Archer calls attention to the work of Merica and Gurevitch,¹ who tentatively suggest a curve of solubility of graphite in austenite which is very close to the corresponding line for cementite in the metastable diagram applied to steels. However, speed of cooling is an important factor in the final result—in other words, white iron annealed at 835 deg. C. for a sufficient time (20 hr.) to produce equilibrium contains approximately 0.84 per cent combined carbon when quickly cooled, but 0.67 per cent when cooled under ashes. The comparatively short time consumed in passing from 835 deg. C. to temperatures well below A_1 (say 650 deg. C.) where decomposition of cementite is vanishingly slow, is sufficient to allow the formation of 0.2 per cent more graphitic carbon.

Now if it be true, as indicated from Archer's experiments, that graphitization can be initiated and completed in white cast iron at temperatures below A_1 , yet on the other hand cannot be completed at temperatures perhaps identical with A_1 , then the accepted phenomena can be satisfactorily explained as follows:

"1. With the possible exception of the initial stages, graphitization takes place directly from solid solution.

"2. Graphitization may take place from any solid solution supersaturated with respect to graphitic carbon.

"3. The evidence at present available is not sufficient to determine whether the saturation values for a solid solution on the point of precipitating graphite are appreciably different from those for a solid solution on the point of precipitating cementite. Under conditions of equilibrium, two phases are present—graphitic carbon and the saturated solid solution. Metastable equilibrium may exist between the two phases iron carbide and solid solution. Theory indicates that the carbon concentration of solutions in stable equilibrium with graphite is less than that of solutions in metastable equilibrium with iron carbide. If the available experimental evidence is considered with allowance for the effect of impurities on the solubility of iron carbide, the solubility curve of the carbide may, for practical purposes, be used to determine the conditions of equilibrium in the stable system iron graphite."

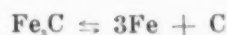
STABLE AND METASTABLE EQUILIBRIUM

A. E. WHITE, while disavowing any intention of discussing whether graphitization takes place from cementite or from solid solution, pointed out that there was nothing unusual about the fact that it proceeded below A_1 , since the stable condition at low temperatures is evidently a system containing iron and graphite. Since the tendency to approach equilibrium is always present at all temperatures, the reheating must be to a degree only sufficient to provide sufficient molecular or atomic mobility for the ever-present tendency to make itself felt. Consequently time is the only requisite for graphitization at temperatures below the critical. In the speaker's opinion the stable equilibrium diagram is delineated with far

from precision, still he introduced evidence strongly supporting Archer's figure of 750 deg. C. for A_1 for standard malleable analyses.

J. V. EMMONS said that graphitization below the critical can easily take place, since he had found particles of carbon occupying the precise position which free cementite had previously occupied in a piece of tempered tool steel. However, since it was extremely doubtful to him whether any solid solution could exist below A_1 , any graphite should result directly from the decomposition of cementite which does exist in very large quantity.

FRANCIS B. FOLEY pointed out the danger of making inferences on insufficient data, saying that another hypothesis accounted as well for the facts brought out in Archer's paper as the one that graphitization proceeded directly from solid solution. That is this: when passing Ac_{cm} the metastable cementite just born immediately breaks up into its constituents according to the reaction



Lag has its well-known effects on this reaction. Quenching prevents precipitation of carbide, and martensite results. Moderate cooling allows cementite to precipitate but not to decompose, while slow cooling favors complete dissociation of the carbide. Time at temperatures below A_1 will allow all free carbon then molecularly dispersed to accumulate in microscopic masses—a condition of total graphitization. Complete graphitization above A_1 is impossible, since the reaction then goes to the left to the saturation of austenite. It follows from this hypothesis that the carbide line and its eutectic are identical with the graphite line and eutectic, a conclusion recently favored by some students of the problem.

In reply to the discussion, Mr. Archer said he still held that the weight of evidence supported the idea that graphite was precipitated from solid solution. It is important to remember that the black masses in malleable iron are not solid carbon but rather layers of graphite carbon occurring between laminations of ferrite—quite similar to eutectic structure. Another ordinary appearance is to be explained, namely, that graphite accumulations are often surrounded by a shell of ferrite, which in turn is embedded in pearlite. Now if free carbon is not an element of the solid solution, how could the graphite arrive in quantity at such a center?

Distortion on Hardening

A paper entitled "Coefficient of Expansion of Alloy Steels" was read by JOHN A. MATHEWS, in which he gave the complete history and physical properties of eleven liberty motor shafts of various analyses, together with the coefficient of expansion up to 270 deg. C., a set of data unfortunately somewhat unique. It is also mentioned that moderate coefficients of expansion such as normal steels possess have not nearly so great an effect on warping during heat treatment as the skill with which the manipulations are conducted. Some special analyses with expansions about the same as ordinary carbon steels will harden entirely free from distortion or volume change, even with moderate care; others give great trouble even when quenched in dies or by machinery. "This again illustrates the fact that the coefficient of expansion, in itself, is not a primary cause of distortion in heat treatment, al-

¹Bulletin, A. I. M. E., No. 151: CHEM. & MET. ENG., vol. 22, p. 49 (Jan. 7, 1920).

though, in general, hardening from a temperature just about that at which the maximum contraction takes place at decalcification would tend to improve the final results of hardening so far as distortion is concerned; this practice is now in use in some progressive plants where the end of decalcification is directly determined from pieces in the furnace rather than by relying upon the reading of the pyrometer located at a more or less remote spot in the furnace."

Nickel Steel

HOWARD SCOTT presented an important contribution on the "Critical Ranges of Some Commercial Nickel Steels," a study of a series of 40-point carbon alloys of great industrial importance. Using inverse rate heating and cooling curves, he was able to plot the effect of nickel up to 4 per cent on the critical ranges of 0.40 per cent carbon steel. In general, increasing nickel decreases the width of the critical ranges on

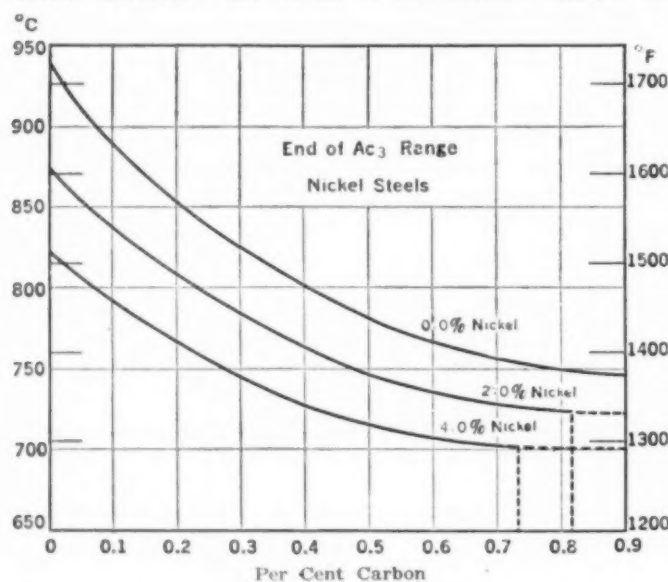


FIG. 1. EFFECT OF CARBON ON END OF Ac_3 FOR 0, 2 AND 4 PER CENT NICKEL

both heating and cooling, decreases the absolute temperature of the critical points, but with greater effect on the $Ar_{3.2}$ range. In particular, $Ac_{3.2}$ for a 40-point steel with no nickel begins at 732 and ends at 800, while if 4 per cent nickel is present the same range begins at 690 and ends at 730. $Ar_{3.2}$ for a 40-point steel with no nickel begins at 672 and ends at 745, while if 4 per cent nickel is present it begins at 587 and ends at 637 (all temperatures being closely approximate and in degrees C.). Quenching experiments show that the end of Ac_3 corresponds substantially to homogeneous austenite solution, consequently the results just quoted may be used as a basis for heat treatment with carbon-nickel steels covering a wide range.

Using in conjunction with the above data some records at the Bureau of Standards showing the effect of carbon on the Ac ranges in plain steels, and accepting the idea that a lowering of the critical ranges for carbon decreases the eutectoid composition, the curves given in Fig. 1 are presented for industrial use. In view of the steep slope for low carbon concentrations, the author emphasizes the fact that soft steels should be held within closer limits than plus or minus 5 points, since the tolerance can easily cause an error of 25 deg. in the subsequent heat treatment.

Forgeability of Iron-Nickel Alloys

A byproduct of an investigation of the magnetic properties of iron-nickel alloys was presented by T. D. YENSEN, in a paper of the above title. He found great difficulty in working pure iron-nickel alloys at ordinary forging temperatures, consequently in order to get a usable magnetic alloy, a composition had to be worked out which could be produced in commercial shapes. Whereas the degree of forgeability of a material depends on the relative strength of the crystalline and the intercrystalline—or amorphous—material, the forgeability of an ingot or casting can be ascertained only by actually attempting to deform the material, either by forging or rolling, or by tensile test. Metallography has not yet reached a stage where an inspection of the microstructure will give any definite information in this respect. Aluminum, carbon, magnesium or silicon was found to have little or no effect upon the forgeability, but the fact that manganese and titanium in amounts equal to 2 per cent of the lesser binary constituent transform iron-nickel alloys from non-forgeable to forgeable alloys means that these elements have the ability to strengthen the amorphous material that is generated between the crystals to such an extent as to make it stronger than the crystalline material.

C. G. FINK said that he investigated the same properties when developing a compound wire with a copper shell over a nickel-iron core. The two had to have about equal ductility so they would deform alike during wire-drawing. All his alloys containing 26 to 60 per cent nickel were very hard, and required continual annealing, but when the most extreme care was used to prevent carbon entering the alloy—even that amount usually introduced by an Arsem "vacuum" furnace—the same alloys could be made so soft they could be whittled with a knife. All the alloys contained manganese, which was necessary for the requisite tenacity.

CRITERION OF FORGEABILITY

ZAY JEFFRIES pointed out that Dr. Yensen's paper needed correction in that the condition of forgeability was not solely the possession of a strong crystalline cement, but, in addition, it should be strong enough to force the crystals to bear strain, and the latter in turn must be capable of being deformed. Thus, lead is forgeable, but not ductile—that is, it cannot be drawn through dies. In this case the cement is not strong enough to hold together and transfer the load to the deformable crystals. Fine grained chromium metal, again, has a very strong cement, but the metal cannot be forged because the crystal cannot be deformed. The rate at which the stress is applied has a great part in determining the apparent mobility of crystal as related to its cementing films, as has often been pointed out before.

Crystallography of Iron

"Microstructure of Iron and Steel at High Temperatures" was discussed by H. S. RAWDON and HOWARD SCOTT, in a profusely illustrated paper, difficult to abstract, but which we hope to publish in full. One of their principal conclusions is that heating *in vacuo* (using a modified Rosenhain furnace) pronouncedly decarburizes both hyper- and hypo-eutectoid steels, an experimental result at complete variance with Dr.

Henry M. Howe's proposition that excess constituent is extruded by austenite crystals to their surfaces.

The various reasons advanced by Dr. Howe to support this hypothesis were reviewed by E. E. THUM, who pointed out that a pseudo-mechanical "elbowing" action did not explain the observed phenomena of movement and agglomeration of insoluble ferrite or cementite as well as the incessant solution and reprecipitation continuing at all times, a balanced action producing equilibrium between any solvent and its solute. In one case only, which Dr. Howe substantiated with micrographs, was the solution theory at fault. That was that pro-eutectoid material tended to line the walls of cavities, either natural or artificial. Even in view of this case Mr. Thum felt that the true test of an "elbowing" action would be evidence that an insoluble particle, like a sonim, had been bodily moved solely by heat treatment.

Drs. F. GIOLITTI and Z. JEFFRIES both said that elbowing of solid materials was to their minds very doubtful, and that they had never seen any evidence that would point to transportation *en masse*; in fact, definite trials at temperatures up to 1,300 deg. C. had caused no bodily movements in the slag. The latter speaker said that some small movement might be caused by the fact that grain boundaries ordinarily contain inclusions, and the crystalline growth is often obstructed by such particles, especially if there were many of them present. Of course some movements in ferrite and cementite were not due to diffusion—for instance, spheroidizing of cementite was doubtless a surface tension effect. But the apparent habitat of pro-eutectoid material at grain boundaries was due in greatest part to the fact that the first portions to separate tend to draw like material to themselves, correspondingly impoverishing the surrounding region.

Changes in Iron at a Blue Heat

ZAY JEFFRIES presented the report of a National Research Council committee on the "Physical Changes in Iron and Steel Below the Thermal Critical Range." After an extended review of the literature on such aspects of the subject as the variation in tensile and electrical properties, the recovery of elasticity after overstrain, the effect of working at blue heat, aging, and low-temperature thermal evolutions, the author concludes that the best substantiated phenomena are well explained by assuming a low-temperature allotrope in iron.

More than a little opposition to this view was apparent, however. HOWARD SCOTT was under the impression that many phenomena simulating the properties of allotropes could be ascribed to a slow but long-continued precipitation of cementite, held at low temperature in metastable solution, an action similar to the aging of duralumin. Blue brittleness and unusual impact values, on the other hand, might be due to a very slight solubility of cementite in ferrite—absolute and complete insolubility is unlikely.

F. C. LANGENBURG also doubted if blue brittleness was more an evidence of allotropy than an inherent property of free ferrite. Honda had found a magnetic change in cementite at low temperatures, which could easily be responsible for many peculiarities in brittle steels—for instance, the improvement under impact of nickel-chromium steels after quenching from 600

deg. C. may result from a considerable content of such carbides.

R. S. ARCHER pointed out that although the α , β and γ states of iron had been established by a study of the physical properties, allotropy involved molecular rearrangement. Such molecular arrangements in nature are known to be simple, yet there were not so very many simple arrangements possible. Most of the evidence regarding elastic recovery after strain could be harmonized with Beilby's amorphous theory, especially since the phenomenon was by no means limited to iron. If a ferrite crystal be overstrained to the point where slip occurs at one plane, the freshly formed amorphous material along that slip plane is very weak and has a low adhesion—which is the reason why slip can take place by stages. This temporary great mobility at any rate passes quickly, and after a time the amorphous phase hardens and the adhesion becomes very great. If, however, the deformation takes place at about 300 deg. C., the hardening of the amorphous phase is much more rapid, with the result that the stress occurs in parallel planes. An equal deformation at this temperature is consequently accompanied by the development of a largely increased number of slip planes, a largely increased proportion of amorphous material, and a correspondingly enhanced brittleness.

F. N. SPELLER asked whether the so-called "crystallization of steel in use" was not another occurrence within the scope of this investigation. It at least apparently involved the formation of considerable amorphous material in such important grades as soft and medium steels. His experience indicated that there were other causes than alternating loads for "crystallization" failures, since granular fractures occurred at places well removed from loci of maximum strain.

W. E. RUDER agreed that magnetic aging was a peculiar fact which a very extensive investigation had failed to explain. The only clue discovered to date was that an annealing in hydrogen nearly but not entirely prevents magnetic aging in low-carbon steels. In such a complex series of evidence, however, he felt that it would be extremely surprising if one simple fact could be discovered which would completely explain it all.

S. L. HOYT argued that if allotropy were the material cause of some discontinuities—such as, for instance, a slight break in the rate of expansion of steel at a blue heat—the fact should be studied in the light of what we know about allotropy. In other words, the transformation should be reversible, and give evidence of lag, especially owing to sluggishness of atomic movement at low temperature. Thus, extensive tests on complete cycles of heating and cooling would be needed to establish Dr. Jeffries' contentions.

The author in reply acknowledged that Langenburg's point was well taken; in fact, he did not contend that blue brittleness of Ni-Cr steels (the so-called Krupp Krankheit) was due to a low-temperature allotrope. However, the peculiar variation of tensile properties with heat cannot be due to a carbide transformation, since they occur in pure iron as well as in steels. Even admitting that the general effect of stress and time is to produce slip bands and subsequent failure by virtue of a local, irreversible deformation, Dr. Jeffries felt that the quantitative effect in iron strained at blue heat was enormously greater

than could be ascribed to a theory similar to that adopted by Archer. In this connection he also called attention to a hypothesis advanced by Radcliffe Furness, that if ferrite goes to grain boundaries at temperatures above the low critical, then the same tendency will persist in sorbitic ferrite at a lower temperature. This tendency, being satisfied to a minute degree, would produce thin films of ductile ferrite at boundaries of sorbite grains, shells which though ductile are much weaker than the kernels they surround. Consequently intracrystalline fracture in such steels will simulate brittleness.

Added Life for Factory Roof Timbers*

It is only necessary for the investigator to view the roof trusses of a number of buildings housing chemical apparatus to note the rapid decay caused by high humidity and the inroads of acid fumes. It is believed that a number of the preservative treatments which are suggested in the following paragraphs, if applied either during construction or after erection, would mean increased returns to the company through added life given to the wood members.

The steeping process of preserving timber consists merely in soaking the timber in a water solution of a preservative such as zinc chloride, sodium fluoride or mercuric chloride. Thoroughly seasoned wood is used and left in the solution one day for each inch in thickness and one additional day.

After treatment the timber should be air dried before using. Zinc chloride attacks lead paint, but is very desirable otherwise. Mercuric chloride is very effective, but is poisonous and has a decided corrosive action on steel, so that steel tanks cannot be used with it. Sodium fluoride does not attack paint, is not corrosive, and in most other respects is very desirable.

Timbers may be coated with coal-tar creosote by brush treatment, by dipping in hot oil from 5 to 15 min., or the hot and cold bath method. This last method consists of submerging the lumber in hot oil for several hours and then either allowing the oil to cool down slowly with the wood in it or plunging the wood into cool oil and leaving it for several hours. This method of preservation is objected to by some insurance companies as a fire hazard, but whether or not it really does add greatly to the inflammability of wood is a debatable question.

Although pressure treatments are the most expensive, they are the most effective, because they result in the greatest absorption and penetration of preservatives. Roof planking should receive 8 to 12 lb. of creosote per cu.ft., or $\frac{1}{2}$ lb. of the salt if zinc chloride is used. Such treatment should add at least 20 yr. to the life of roof planks.

The effectiveness of treating timbers depends upon maintaining a complete envelope of treated wood around the untreated interior of the piece. If this treated layer is broken through, decay can enter and destroy the untreated interior in spite of the treated outer layer. For this reason lumber should be cut to final dimensions before treatment. Whenever it does become necessary to cut into treated timber, the untreated wood exposed by cutting should be given two fresh coats of creosote or some other preservative.

* Abstracted from Forest Products Laboratory "Technical Notes."

American Institute of Baking

The American Institute of Baking, founded by the American Association of the Baking Industry, has begun work in Minneapolis under the direction of Dr. H. E. Barnard, assisted by an advisory committee of the National Research Council and in co-operation with the Dunwoody Institute. Dr. Barnard has been connected with the State Board of Health of Indiana for nearly nineteen years and was Federal food administrator of that state during the war.

For thousands of years bread-making has been a craft rather than a science, and in all its essentials and in many of its details it has remained practically unchanged for ages. The attempt is now to be made to make bread-making a science, or at least to found it on science. Some of the larger baking companies have already tested the value of science as applied to their business, and one of these companies, using more than a million barrels of flour a year, has introduced methods leading to great economies in its work. It was found that by furnishing the yeast with certain stimulants and special chemical foods a saving of some of both the flour and sugar formerly consumed by the yeast during its growth was made. This is not only a saving to the baker but also a conservation of valuable human food materials without any diminution in the quality or food value of the bread.

However, but few of the 28,000 bakers in the United States are in a position to conduct scientific experiments or to have them conducted for them separately. Of these 28,000 bakers, only 7,500 use more than 50 bbl. of flour a month, while only 2,500 use more than 200 bbl. a month. For each one of these bakers to try to engage in scientific research would obviously result in a waste of effort even if the expenses could be met, but by working in co-operation, as now arranged by the new Institute of Baking with the scientific aid of the specialists on food and nutrition, agriculture, chemistry and physics of the advisory committee of the National Research Council, all of these bakers can get the advantage of a strong scientific effort for the rational improvement of their methods.

War Zone Reconstruction

The European technical press estimates that there was over 3,000,000 tons of copper thrown from artillery in France and Belgium, and 100 tons of steel per acre (250 tons per hectare) buried in large districts where heavy bombardment persisted. One-third of the total copper and a much larger percentage of the steel will be recovered.

Reconstruction in the French steel and iron industry will require from eight to ten years, mainly because the towns in which the plants are located were 98 per cent destroyed. While nothing has been done toward clearing away the debris around the large steel plants, out of the 500 smaller metal-treating and fabricating plants of the regions 47 per cent have resumed operation, employing, however, only 14 per cent of the original working force.

The damage in the Lens coal district is estimated as 80 per cent of the total valuation of the property. Before pumping can be commenced the holes in concrete shaft linings and tunnels must be discovered and restored, as no headway can be made against the seepage in the moist territory surrounding until this is done.

A Contribution to the Study of Flotation

An Analysis of Circumstances Connected With a Paper by H. L. Sulman in the "Transactions" of the Institution of Mining and Metallurgy—Doubt Cast on the Reliability and Sincerity of the Contribution

By AN OCCASIONAL CONTRIBUTOR

THERE has recently appeared in the *Transactions* of the Institution of Mining and Metallurgy a paper by H. L. Sulman entitled "A Contribution to the Study of Flotation," which, because of the many circumstances surrounding its origin, requires more careful and dispassionate scrutiny to give it the value in technical literature which should be attached to it than any other paper appearing in recent years.

Mr. Sulman is a past president of the Institution of Mining and Metallurgy and in the part which he has taken in the discussions at the Institution's meetings he has shown himself to be an astute student of science. But he has also occupied another relationship to the development of science and industry, in that he has been engaged in the invention and patenting of processes of ore-treatment and is now and for years past has continuously been in the employ of one of the most widely known companies which has patented and exploited concentration processes.

The greatest of all Teachers long since uttered a truth of universal application when He said: "No man can serve two masters, for either he will hate the one and love the other, or else he will hold to one and despise the other. Ye cannot serve God and Mammon."

Let us look into the facts in the case and, if we can, ascertain which master Mr. Sulman is serving at this time.

H. L. Sulman and H. F. K. Picard wrote a treatise on flotation concentration some years since. In the preface of the first edition of his work entitled "Concentration of Ores by Flotation," published in July, 1912, Theodore J. Hoover, now professor of mining and metallurgy at Leland Stanford Junior University, states:

To H. Livingstone Sulman and Hugh F. K. Picard, of the firm of Sulman & Picard, I am indebted for many ideas absorbed from them through three years of pleasant professional association, during which time they were consulting metallurgists to the above company (i.e., Minerals Separation, Ltd.). They have in preparation a book on the "Theories of Concentration Processes Involving Surface Tension," which will be a work of high scientific merit. I have endeavored, I hope successfully, not to trespass on any new and unpublished ground, the announcement of which rightfully belongs to them; further it is not my desire to present the subject in so profound a manner as they will do, deeming it of considerable more use to engineers to leave for another occasion the discussion of mathematical and physical laws involved.

In the third edition of the same work, published in 1916, Mr. Hoover says on pages 257 and 258:

G. D. Van Arsdale has given some excellent results of his investigation of surface films and contact angles, and brings the solution of a number of hitherto unsolved problems measurably nearer. Without detracting in the least from the merit of his work, or in any way depreciating his discoveries, it is only right to say that these things and many others of equal, if not greater, importance to science have been discovered

and clearly and definitely quantified by H. L. Sulman and H. F. K. Picard. As mentioned in the preface to the first edition, they have for years been working on the physical factors involved in flotation processes, and have had for many years a voluminous work completed and ready for publication.

This manuscript is among the archives of the Minerals Separation, Ltd., who adopt the attitude, in this case, of censors. If it is the intention of the company to regard themselves as being in a state of war against the whole metallurgical industry, there might be some justification for an embargo on the publication of scientific information; but they have received at the hands of the state a valuable monopoly in a great industry, against which they should not wage war; but, on the contrary, they should act with frankness and candor toward those with whom they seek to do business, and from whom they expect to draw the revenue assured to them by their monopoly.

Mr. Hoover's references to this book indicate such familiarity with its contents as could only come from a detailed and continued study of it.

In the *Mining Magazine*,² in an editorial upon the presentation of Mr. Sulman's paper to the Institution, we read in part as follows:

And here it is appropriate for us to say that the reading of the paper has been delayed many years, owing to the litigation in connection with Minerals Separation's patents. In the meantime other investigators have published views and theories, and they and their friends have prided themselves that they knew more of the physics of the process than the original patentees. But though Mr. Sulman never wrote anything on the subject, he was immersed in study and research from the beginning. A dozen years ago the present writer saw a book³ which Mr. Sulman had ready for publication. All the diagrams figuring in the paper were in this book, as well as the word "hysteresis," which Prof. Boys said the other night was invented three years ago. Naturally much research has been done since then, and the services of the principles of colloid chemistry and adsorption have been requisitioned. But the fact remains that Mr. Sulman was a pioneer in the scientific study of the physics of the process as well as an inventor of the successful process.

The *Bulletin* of the Institution of Mining and Metallurgy for January, 1920, is given up largely to a discussion of Mr. Sulman's paper and to a paper by Walter Broadbridge entitled "Froth Flotation—Its Commercial Application and Its Influence on Modern Concentration and Smelting Practice."

The comments upon the Sulman paper vary from the laudatory to the most sharply critical.

Sir Thomas K. Rose, whose "Metallurgy of Gold" has long been considered a classic and an authority, commented that "he had heard that Mr. Sulman had written a book on the subject, ten or twelve years ago, which had never been published, and that most of the paper was contained in it. He wished he could have seen that twelve years ago, because by this time he might have been in a position to discuss the matter usefully."⁴

²*Mining Magazine*, December, 1919, p. 323.

³This was probably a copy of the treatise referred to in Hoover's "Concentration of Ores by Flotation."

⁴*Bull. I. M. M.*, January, 1920, p. 10.

¹*Bulletin* Institution of Mining and Metallurgy, November, 1919.

Sir Thomas also commented upon the fact that the paper should have contained some data upon which is based the revelation that cassiterite has been proved to be concentratable by flotation.

E. Hatschek reviews the Sulman paper *in extenso* from the standpoint of the physicist,⁶ and differs from many of the author's conclusions. He states, in italics, that the "*facts are incorrectly stated in every essential particular*" (p. 75) as regards the fundamental phenomenon, cataphoresis. (*Ibid.*, p. 19.)

He further comments: "Considering the large amount of theoretical matter of an elementary nature which Mr. Sulman has included in his paper, there is a surprising absence of reference to recent work which has the closest bearing on several of the issues raised in it."

In an editorial in the *Mining and Scientific Press*,⁷ T. A. Rickard says:

We think it proper to record a strong protest against Mr. Sulman's unscholarly failure to make the customary references to previous writers on his subject. In the concluding paragraph of the paper he excuses himself for his lapse of good manners by presenting a bouquet to his business associate, John Ballot, until recently the chairman of Minerals Separation, Ltd. Mr. Sulman describes his partner as "one of the original inventors" of the process, when it is well known, on the evidence of Mr. Ballot himself, that he merely instructed a member of his staff, A. H. Higgins, to make a series of experiments, ringing the changes on various proportions of oil, rates of agitation, and so forth, the consequence being to confirm the results obtained a year before by F. A. Beauchamp and Wilton Shellshear in the Central mill at Broken Hill—results of which Mr. Ballot must necessarily have been aware, because his own representative, G. A. Chapman, was on the spot and participating in the Australian experiments.

In replying to the criticisms of his paper Sulman says:⁸ "Mr. Hatschek is correct as to my faultiness in matters of form. I am aware that many references are lacking; as before stated, these will be inserted in any reprint of the paper. I also feel that apologies are due for several misprints and for one or two obvious slips; I can only urge that the paper was written under considerable pressure as to time, and that my reading of the proofs was similarly hurried."

SULMAN SCIENTIST A SULMAN PROTAGONIST?

All of which tends to but deepen the mystery. As has been previously stated, it is known that many years ago Sulman and Picard had "completed and ready for publication" a book on "Theories of Concentration Processes Involving Surface Tension," "which will be a work of high scientific merit."⁹ Yet in 1919 we find a paper coming out under the signature of Sulman alone and in a form which Mr. Sulman admits is occasion for apology because of the hastiness and unworkmanlike shape in which it is presented.

It is inconceivable that it is Mr. Sulman, devotee of science, who has not found the time in a dozen years in which to prepare his paper according to the conventions observed by scientists in the presentation of "contributions" to knowledge.

Is it not possible that it is Mr. Sulman, follower of the law and the profits, who has answered an emergency call to publish something promptly which will answer the accusation that his employers have steadily placed a brake upon the spread of knowledge and the development of science? And is it not possible that Mr.

Picard, who we have been assured was a co-author with Mr. Sulman in the writing of a treatise prepared years ago, finds it impossible or impolitic to appear as co-author of the paper now hurriedly published?

That these things may be true is suggested by the fact that these gentlemen have for years been debarred from publishing their original scientific treatise by their employer, Minerals Separation, Ltd., which company has been litigating their patents for many years. The suppression of the publication of what is alleged to be a purely scientific treatise strongly suggests that the claims which Minerals Separation, Ltd., has been attempting to establish in the courts have in fact the insecure foundation which has been credited to them by the American mining industry. For if they could stand the full light of science there would never have been any reason for suppressing a scientific discussion of the physical basis of flotation.

AMERICAN BRANCH OF MINERALS SEPARATION, LTD., UNDER FEDERAL SCRUTINY

The Federal Trade Commission of the United States of America has had the American branch of Minerals Separation, Ltd., under most careful scrutiny. George L. Nye, special counsel for the American Mining Congress in the Federal Trade Commission inquiry, at the St. Louis Convention of the American Mining Congress points out¹⁰ that the British employers of Mr. Sulman were throughout most of the World War maintaining commercial relations with Beer, Sondheimer & Co., and taking all necessary crafty steps to see that that German company which was on the British blacklist should reap the full benefits of its part ownership and management of Minerals Separation's patents. This should be a shock to all good Britishers and be given most serious consideration by the loyal British members of the Institution of Mining and Metallurgy.

Mr. Nye also calls attention to the fact that the license contract issued by Minerals Separation, Ltd., to users of the process covered by its patents "provides that the licensee shall not, without the consent of licensor, communicate any details connected with the working of any of said inventions, modifications, additions, or improvements to any third party. This again emphasizes the restraint imposed by Minerals Separation, Ltd., upon any dissemination of information except under its direction and control. This restraint upon the spread of knowledge is not only adverse to the public interests but is certainly against public policy."¹¹

May not this well merited criticism of the suppression of knowledge by one chosen to represent the whole American mining industry, and the investigation by the Federal Trade Commission explain the panic to publish something sounding very scientific, which led to the hasty and slovenly preparation of the Sulman paper?

May not the same necessity for camouflage also explain the appearance in the *Bulletin* of the Institution for January, 1920, of a paper by Mr. Broadbridge, general manager for Minerals Separation, Ltd., which, like the Sulman paper, creates the impression that information of value is being furnished when it is not, and which errs fully as flagrantly as does Mr. Sulman's paper in not giving proper credit to the various engineers who have contributed to making flotation concentration an established art?

⁶*Bull.*, I. M. M., Jan. 20, 1920, p. 16 et seq.

⁷*Mining and Scientific Press*, Dec. 13, 1919, p. 840.

⁸*Trans.*, I. M. M., January, 1920, p. 48.

⁹Hoover, "Concentrating Ores by Flotation," third ed., p. 258.

¹⁰*Mining and Scientific Press*, Dec. 13, 1919.

¹¹*Mining and Scientific Press*, Dec. 13, 1919, p. 852.

The Effect of Nitrogen on Steel

A Résumé of the Important Literature on Amount of Nitrogen in Various Classes of Steels, Its Method of Occurrence and Effect on Physical Properties, Together With Some Recent Experiments on Its Action During Heat Treatment

BY GEORGE F. COMSTOCK* AND W. E. RUDER†

THE subject of the influence of nitrogen on steel is one that has awakened scant interest among metallurgists until quite recent years, because in spite of the undoubtedly strong effect of this element when presented in small amounts in iron, the amounts actually found in commercial products are generally so excessively minute that even their determination is difficult and the assignment of definite effects to them is nearly impossible in the presence of so many more potent disturbing factors. Perhaps in no other branch of ferrous metallurgy is the conflict between the theorists or laboratory workers and the practical men more pronounced; for in laboratory tests nitrogen appears to be one of the most detrimental of all impurities in steel, while in commercial practice it has not been easy to show any consistent effect. An outline of the published researches on nitrogen in steel will be given below to show the state of our knowledge of the subject at the present time.

EARLY WORK

One of the earliest references to this subject is a paper by A. H. Allen in the *Journal, Iron and Steel Institute* for 1880 (No. 1, p. 181), where an analytical method for nitrogen in steel is given, and results are quoted that indicate its presence in all ordinary steel. The effects of nitrogen were not described in this paper, but in 1887 an article by H. N. Warren in *Chemical News* (vol. 55, p. 155) mentioned the fact that great brittleness could be caused in steel by nitrogen absorbed during heating to a bright red in an atmosphere of ammonia. It was stated that only 0.5 per cent of nitrogen would make steel bars so brittle as to break when dropped from a height of 6 ft. In 1889 H. Tholander published an article in *Jernkontorets Annaler* (vol. 43, No. 7) discussing the practical effects of nitrogen in commercial steel. He found 0.012 to 0.022 per cent nitrogen in bessemer "ingot iron," and 0.005 to 0.013 per cent in open-hearth steel plate, stating his opinion that the difference in quality between these grades of steel was largely due to the difference in nitrogen content. He also suggested that the damage done by overblowing bessemer metal was due to nitrogen absorption rather than to over-oxidation.

In regard to the form in which nitrogen exists in steel, G. I. Fowler in 1894 published an article in *Chemical News* (vol. 68, p. 152) stating his agreement with an earlier writer, Stahlschmidt, that only one nitride of iron, Fe_3N_2 , exists. Two years later a "Note on the Presence of Fixed Nitrogen in Steel," by Harbord and Twynam, appeared in the *Journal, Iron and Steel Institute* (1896, No. 2, p. 161), recognizing that nitrogen may be both mechanically occluded and chemically com-

bined in steel. They investigated the presence in steel of Mn_3N_2 , which compound is formed when manganese is heated in nitrogen, but could find no proof of its occurrence in steel. Good average steel was found to contain from 0.006 to 0.017 per cent nitrogen, and no difference in the content of this element was found between bessemer and open-hearth steel, although crucible steel was found to contain less. No connection was found between the nitrogen content and the quality of the steel, although one rail which failed from a flaw was found to be unusually high in nitrogen.

BRAUNE'S PUBLICATIONS IN 1905

After this preliminary work, no more important papers appeared on nitrogen until 1905, when H. Braune published several articles (*Stahl und Eisen*, vol. 25, p. 1,195; *Revue de Metallurgie*, 1905, p. 497; *Jernkontorets Annaler*, vol. 59, p. 636) discussing the influence of nitrogen on iron. He found that nitrogen increased the strength but decreased the elongation of iron. From 0.02 to 0.062 per cent was found in commercial steels. In general it did not have much effect on low-carbon wrought-iron; but in ingot metal or steel 0.035 per cent nitrogen was enough to destroy the elongation when the carbon was high, 0.045 per cent destroyed the elongation of 0.50 per cent carbon steel, and 0.06 per cent made soft acid bessemer steel brittle. Nitrogen was found to affect the magnetic properties the same as carbon. It was thought to occur as the nitride Fe_3N_2 in solid solution in ferrite. When 0.075 per cent nitrogen was present, the grain-size was reduced to one-tenth its normal size, and a brittle substance began to appear at the boundaries. With 0.2 per cent, the steel had a pearlitic appearance, or, as discussed by Le Chatelier, it may be said to show Neumann's lines which were often found by Osmond in brittle steel. Braune stated that steel will absorb nitrogen in every metallurgical process with high temperature, basic slag, and reducing conditions or in presence of carbon. He described a case where nitrogen produced brittleness in Lancashire hearth-iron made from pig coming from a blast furnace that produced large quantities of cyanide.

BRAUNE'S WORK CRITICIZED

This work of Braune was rather severely criticized in several quarters, Pourcel in the *Revue Universelle des Mines* (vol. 15, p. 229) contending Braune's statements were not probable, that nitrogen would be absorbed or retained in steel made in the oxidizing atmosphere of both bessemer and open-hearth processes. Grabe in *Revue de Metallurgie* (vol. 5, p. 353) and Petren and Grabe in *Jernkontorets Annaler* (vol. 60, p. 1) maintained that Braune's chemical methods were incorrect, giving too high results for nitrogen. They conclude that the minute percentages of nitrogen actually existing in

*Metallurgist, Titanium Alloy Manufacturing Co.
†Metallurgist, General Electric Co.

commercial steels had no influence on mechanical quality.

The first of the *Carnegie Scholarship Memoirs* (1909) of the Iron and Steel Institute contain some notes on the "Influence of Nitrogen on Steel," by Walter Geisen. He states that the elongation of steel entirely disappears with an increase in nitrogen from 0.037 to 0.041 per cent, and that hard steels are more sensitive to nitrogen than soft ones. The superiority of crucible steel was explained by its low nitrogen content, and vanadium's value in steel was thought to be due to its removal of nitrogen.

NITROGEN AND PHOSPHORUS IN BOILER PLATE

The next important reference to nitrogen in steel is C. E. Stromeyer's work, published in the *Journal*, Iron and Steel Institute (1909, No. 1, p. 404) under the title "Aging of Mild Steel and Influence of Nitrogen." In his exhaustive investigation of the effect of aging on steel, no reason was found by tests for the occasional brittleness of plates failing in service, except the influence of phosphorus and nitrogen. The worst steels were found to contain either the highest nitrogen or phosphorus, or both, and nitrogen was found to have a much greater effect than phosphorus. Results from cold bend tests by impact on plates previously bent at a blue heat were found to depend distinctly on nitrogen and phosphorus, and it was advised that these elements be reduced as low as possible in high-class boiler steels. The following suggestive formula for the tenacity of such steel in tons per sq.in. is advanced by Stromeyer:

$$T = 17.2 + 35C + 10Si + 2.5(Mn - 1.72S) + 30P + 300N$$

In another paper, before the British Institute of Naval Architects in 1910, the same author stated that the sum of the phosphorus content plus five times the nitrogen content should not exceed 0.08 per cent in good mild plate steel. He also mentioned some boiler plate that appeared very bad in tests, although containing only 0.047 per cent phosphorus; but it had 0.0123 per cent nitrogen, over twice as much as was found in good mild plate steel.

Stromeyer's conclusions were, however, not accepted in some quarters, Saniter especially throwing considerable doubt on them in discussing the paper. It was pointed out by him that all Stromeyer's steels were quite pure, and others had found good steel to contain more nitrogen than was shown by his samples. Furthermore by not considering the samples with over 0.06 per cent phosphorus, he showed that Stromeyer's results on bending did not really bear much relation to the nitrogen contents, or to the phosphorus plus five times the nitrogen, which was the merit figure used by Stromeyer.

NITROGEN'S INFLUENCE ON STEEL

An interesting letter in *METALLURGICAL & CHEMICAL ENGINEERING* (vol. 11, 1913, p. 121) by "E. D. A." entitled "Nitrogen, Its Influence on Steel," also discusses these results. This letter admits that in general nitrogen promotes brittleness in steel, although the manner in which this is effected is not known. In various steels the nitrogen content was found to run from 0.003 to 0.014 per cent. Open-hearth steels averaged lowest in nitrogen, electric steels next, and one bessemer rail showed the most. One electric steel treated with ferrotitanium showed less nitrogen than the untreated average. In comparing actual physical test results with Stromeyer's merit figures derived from the nitrogen

contents as mentioned above, the latter were found to be of small significance, as two out of the three best steels stood lowest in regard to the phosphorus and nitrogen merit figure. Merit figures are thus concluded to be not uniform or consistent.

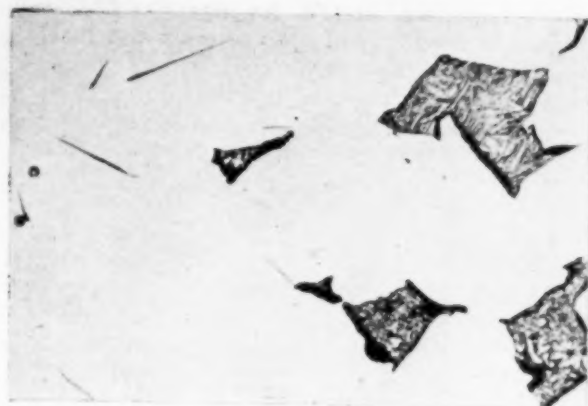
SUPPRESSION OF TRANSFORMATIONS BY NITROGEN

Probably the most important work that has been done along theoretical or laboratory lines on nitrogen in steel is that by J. H. Andrew, published in two papers by the Iron and Steel Institute. One of these was on "The Influence of Gases Upon the Critical Ranges of the Iron-Carbon Alloys," published in the *Carnegie Scholarship Memoirs* (vol. 3, 1911, p. 236); the second was entitled "Iron and Nitrogen" and appeared in the *Journal* (1912, No. 2, p. 210). Andrew found that heating and cooling in ammonia gas had a marked effect on the critical points of steel, which effect was overcome by reheating a number of times *in vacuo*. The effect was explained by his finding that while CO, CO₂, and hydrogen had no action on the critical changes in iron, 0.3 per cent nitrogen entirely suppressed them. In a 0.60 per cent carbon steel, 0.25 per cent nitrogen lowered the A_r point decidedly. The embrittling effect of nitrogen on steel was considered due to the tendency of the dissolved nitride to retain iron in the gamma state and the carbide in solution. Only a very small amount of nitrogen is needed, and the nitride is not unstable, remelting or prolonged heating *in vacuo* being necessary to extract it all. Iron nitride was considered by Andrew to prevent the coalescence of the iron molecules at the critical point, thus retarding the changes. Iron and iron-carbon alloys were found to absorb small amounts of nitrogen when melted under a high pressure of the gas, so that ammonia is not essential to this absorption.

NEEDLES, NEUMANN'S OR SLIP BANDS

Photomicrographs of nitrogenized iron are given by Andrew, showing needles called Neumann lines, and near the edges of the sample a pearlitic structure with a dark needle-like constituent and a pale yellow substance surrounding it. A quickly cooled specimen with 0.16 per cent carbon, nitrogenized while molten, showed a white constituent like cementite. This was stated not to be pure nitride or carbide, because the sample showed neither critical points nor carbide change; but it was considered a solution of iron-nitride in iron. Dr. E. Colver-Glauert, in a rather theoretical discussion of Andrew's paper, stated that he considered the needles or cementite-like substance to be nitride of iron, and he believed the carbon was expelled from the steel, probably as a cyanide, during the nitrogenizing treatment, and was not dissolved in the steel or nitride.

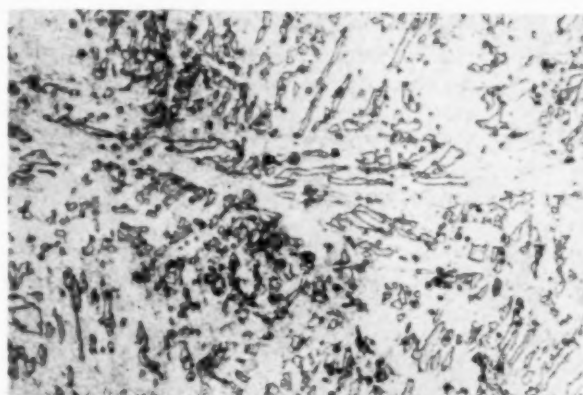
A German investigation of nitrogen in steel by B. Strauss (*Stahl und Eisen*, 1914, vol. 34, p. 1814, and *Iron Age*, 1916, vol. 97, p. 432) resulted in the conclusions that it raised the elastic limit and tensile strength, but reduced the ductility; also that it impaired the magnetic properties, raising the hysteresis and coercive force, and lowering the permeability. This writer thought the needles or Neumann lines in nitrogenized iron were slip bands due to brittleness of the iron caused by solution of nitrogen in it, the slips being produced in polishing or cutting the specimens. Pearlitic and other structures were described due to the combination of nitrogen with carbon in steel, and it was stated that the nitrogen was quickly given off from the steel by annealing in air, hydrogen, or vacuum.



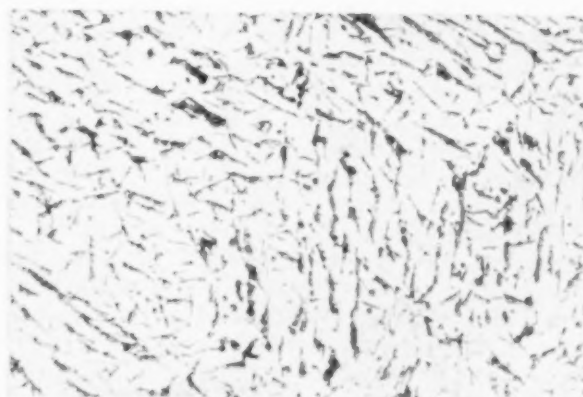
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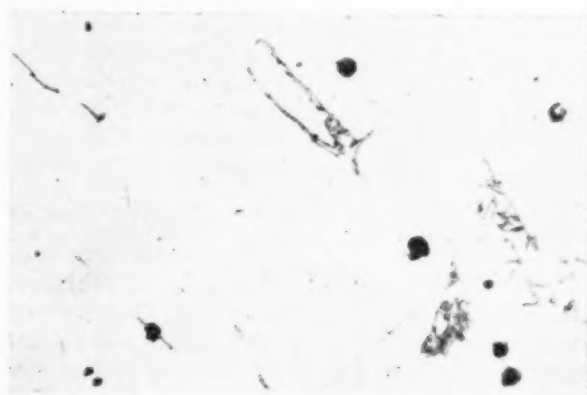
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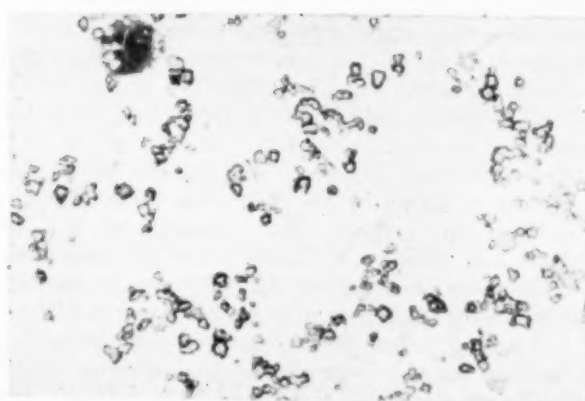
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Fig. 1—Nitrogen forming needles and laminated patches. Fig. 2—Nitrogen in laminated area. Fig. 3—Nitrogen in rapidly cooled arc weld. Fig. 4—Nitrogen in slowly cooled arc weld. Fig. 5—Nitrogen particles in full blown bessemer metal. Fig. 6—Titanium nitride in 0.50 per cent C electric steel. Fig. 7—Titanium nitride in special arc weld. Fig. 2 \times 1,200. Fig. 6 \times 200. Others \times 400.

A voluminous treatise on "The Occurrence and Influence of Nitrogen on Iron and Steel," by N. Tschischewski, appeared recently in the *Journal, Iron and Steel Institute* (1915, No. 2, p. 47). The author considered that the injurious influence of nitrogen on the mechanical properties of iron had then been firmly proved. He found that it increased hardness, reduced elasticity, and caused cold-shortness in steel; and that bessemer steel contained five times as much nitrogen as open-hearth. Metallographic work on iron nitrogenized in the laboratory with ammonia showed a very brittle outer film, found to contain 11 per cent nitrogen, which was considered to be the compound Fe_3N . A hard, less brittle layer below was considered Fe_3N , with 2 per cent nitrogen. The needles in the interior were believed to be this compound. Different structures were found due to different rates of cooling: needles, or spots like a eutectic, or even massive like martensite when quenched. Nitrogen was said to be indistinguishable under the microscope when present in less quantity than 0.05 per cent. Wire with 0.3 per cent nitrogen was very brittle.

In the discussion of this paper both Stead and Stromeier agreed that bessemer steel contained more nitrogen than open-hearth. It was suggested that the form in which nitrogen occurred in the steel, whether uniformly distributed or around the grains, would have an important influence on its effects on the properties; also the nitrogen absorbed from ammonia might have a different effect than that added directly from air as in a converter. Stead considered that temperature conditions must affect the absorption of nitrogen in practice. Pourcel considered this paper impractical, as ordinary steel never contained over 0.015 per cent nitrogen, and higher contents than this, as sometimes found in titanium steels, never did any harm. Even nitrogenized steel showed only about 0.015 per cent nitrogen after remelting.

It was brought out in connection with this paper that a committee of prominent English metallurgists are investigating this subject of nitrogen in steel thoroughly, to decide between the conflicting reports, and they should have their final opinion published soon.

REMOVAL BY TITANIUM OR VANADIUM

Another interesting reference to nitrogen in steel is an abstract of an article by Tschischewski and Blinow in *Revue de Metallurgie* (Extraits, 1915, vol. 12, p. 473). It was found by these investigators that neither 33.5 per cent ferrovanadium nor metallic titanium 83.2 per cent pure removed nitrogen from iron, but formed soluble nitrides, thus sometimes even increasing the nitrogen content, especially in the presence of manganese and silicon. They advised a shortening of the melting period of titanium or vanadium steels to prevent the absorption of too much nitrogen.

Their conclusions, however, are directly at variance with results obtained by the Titanium Alloy Manufacturing Co. on nitrogen in titanium-treated and untreated rail steels. A dozen pairs of open-hearth steel rails were investigated for nitrogen in the company's laboratory; each sample representing a different heat, but each titanium-treated sample coming from the same rolling as the corresponding untreated sample. Practically all these samples were "A" rails, or from the tops of ingots, and the treated steels received 0.1 per cent metallic titanium in the form of ferro-carbon-titanium alloy in the ladle. They were analyzed according to the method described by L. E. Barton in the *Journal*

of *Industrial and Engineering Chemistry*, vol. 6, p. 1,012 ("Improved Method for the Determination of Nitrogen in Steel"), and the writer is also indebted to Mr. Barton for the results tabulated in Table I and obtained under his personal supervision.

TABLE I. NITROGEN CONTENTS OF OPEN-HEARTH RAILS

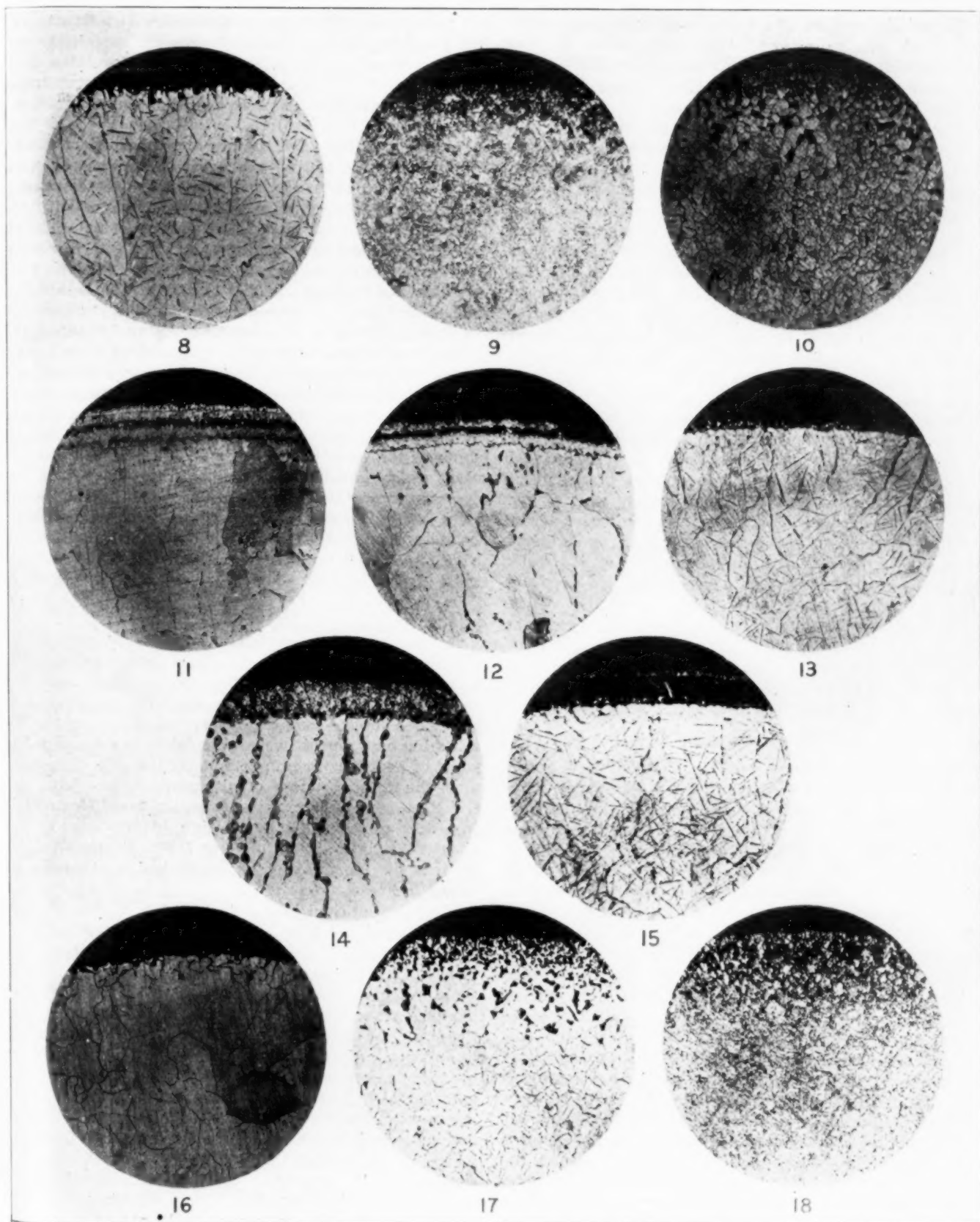
Mill	Rolling	Untreated Samples	Titanium-treated Samples
A	1	0.0038	0.0027
A	2	0.0054	0.0035
		0.0047	0.0044
A	3	0.0039	0.0035
		0.0034	0.0031
A	4	0.0040	0.0032
A	5	0.0048	0.0038
B	1	0.0056	0.0034
B	2	0.0059	0.0029
B	3	0.0046	0.0046
B	4	0.0048	0.0040
Average.....		0.0046	0.0035

These figures show a quite consistent decrease in nitrogen content in the titanium-treated steels, and indicate without much doubt that titanium has an influence on nitrogen in steel. In bessemer and electric steel considerably more nitrogen has been found, the results usually being around 0.02 per cent. This agrees with the conclusions of most other investigators, that in the bessemer process where air is blown through the steel, or in the reducing conditions of the electric furnace, more nitrogen is absorbed than in the oxidizing open hearth, where the slag intervenes between the air and metal.

On Nov. 12, 1918, the Faraday Society held a general discussion on occlusion of gases by metals, and this subject was covered thoroughly by several authorities. Most of the discussion was, however, along the lines of the contamination of metals by all gases in general, and the effects and prevention of the resulting unsoundness. Sir Robert Hadfield in the introductory remarks of this symposium reviewed some of the previous important work on the subject, and gave a bibliography including the work on nitrogen in steel, as well as on the general subject of the occlusion of gases.

NITROGEN IN FUSION WELDS

The recent increase in interest in the art of fusion welding of steel by the arc or oxy-acetylene processes, on account of their use in place of riveting in ship construction, has caused attention to be drawn to the absorption of nitrogen during this operation. One of the earliest articles dealing with this phase of the nitrogen question was that by B. Strauss mentioned above, which appeared first in *Stahl und Eisen*, and was abstracted later in the *Iron Age* (1916, vol. 97, p. 432). Another was written by S. W. Miller, entitled "Some Structures in Steel Fusion Welds" which appeared in the *Transactions* (1918, vol. 58, p. 700), American Institute of Mining Engineers. Miller gave numerous illustrations and careful descriptions of the needles and other structures due to nitrogen occurring in iron deposited in his welds, but he then considered that the constituent producing these structures was cementite. Later he admitted that the needles, etc., were probably due to nitrogen, and in another paper, "Path of Rupture in Steel Fusion Welds" (*Bulletin*, American Institute of Mining Engineers, No. 146, Feb., 1919, p. 311), he gave another interesting series of illustrations of these structures. He reached the conclusion here that the brittleness of steel fusion welds was primarily due not to the needles or other forms of occurrence of nitrogen, but to extremely thin intercrystalline films presumably of oxide.



Heat Treatment of Nitrogenized Iron

Fig. 8—Vacuum fused electrolytic iron, nitrogenized in NH_3 .

Fig. 9—Same metal as Fig. 8, heated to 600 deg. C. for 15 min., quenched in water.

Fig. 10—Same bar as shown in Fig. 9, after being heated to 600 deg. C. and quenched in water, then reheated to 600 deg. C. and slowly cooled.

Fig. 11—Same metal as Fig. 8, heated to 700 deg. C. for 15 min., quenched in water.

Fig. 12—Same as Fig. 11, more deeply etched.

Fig. 13—Same bar as shown in Fig. 11, after being heated to 700 deg. C. for 15 min. and quenched, then reheated to the same temperature and slowly cooled.

Fig. 14—Same metal as Fig. 8, heated to 800 deg. C. for 15 min. and then quenched in water.

Fig. 15—Same bar as shown in Fig. 14, after being heated to 800 deg. C. for 15 min. and quenched in water, then reheated to the same temperature and slowly cooled.

Fig. 16—Same metal as Fig. 8, heated to 950 deg. C. for 15 min. and quenched in water.

Fig. 17—Same bar as shown in Fig. 16, after being heated to 950 deg. C. for 15 min. and quenched in water, then reheated to the same temperature and slowly cooled.

Fig. 18—Same metal as Fig. 8, annealed at 1,000 deg. C. for 15 min. and slowly cooled.

All $\times 50$.

The microstructure of a fusion weld containing nitrogen, both as made and after heat-treatment, was described in a paper by G. F. Comstock entitled "Microstructure of Iron Deposited by Electric Arc Welding" in the January, 1919, *Bulletin*, American Institute of Mining Engineers (No. 145, p. 43). It was found that the nitride was not easily removed from the steel by heating in air, and that there is no simple metallographic method for distinguishing between iron nitride and carbide (cementite) in steel. A more comprehensive description of the structures of nitrogenized iron and iron deposited by the electric arc was given in an article by W. E. Ruder, "The Metallurgy of the Arc Weld," published in the December, 1918, number of *General Electric Review* (vol. 21, p. 941). Nitrogen is here stated to occur in iron in the form of lines or plates, or as dark eutectoid patches not unlike pearlite, or as a cement between the grains. In carbon steels there may be no metallographic evidence of nitrogen, although 0.15 per cent may actually be present. As little as 0.06 per cent nitrogen will reduce the elongation of a 0.20 per cent carbon steel from 28 per cent to 5 per cent. In regular steel it is present in only very small amounts (0.02 per cent in bessemer to 0.005 per cent in open-hearth), but under the conditions of arc welding it seems to become much more active, and combines either directly with the iron vapor or indirectly by means of nitrogen-oxygen compounds. Ruder states that both nitrides and oxides must be removed before such a weld can be ductile, but no scavenging agent has yet been found which will retain any efficacy after passing through the arc. Various experiments are described by Ruder which resulted in proving that the lines or needles found in welds are certainly due to nitrogen.

MICROSCOPY

Some photomicrographs are included in this article to illustrate some of the structures produced by nitrogen in steel. Fig. 1 shows some iron specially nitrogenized in the General Electric Co.'s laboratory, illustrating two forms of occurrence, needles and pearlitic masses. This specimen was etched with boiling alkaline sodium picrate to darken the nitride, and was photographed at a magnification of 400 diameters. Fig. 2 shows one of the pearlitic masses in the same specimen magnified three times as much. Figs. 3 and 4 show two modes of occurrence of nitrogen in an electric arc weld, both taken at a magnification of 400 diameters after etching with nitric acid. The former shows the weld as made, cooled very rapidly by the cold steel plate that was welded; the latter is a slightly annealed specimen cooled more slowly. Fig. 5 shows some needles or small particles of nitride found in bessemer blown metal cast without deoxidation or recarburization. The sample was of course very porous, and full of oxide globules. This was etched with picric acid and magnified 400 diameters. Figs. 6 and 7 show typical crystals of titanium nitride in steel, both unetched, the former in a titanium-treated 0.50 per cent carbon electric steel, magnified 200 diameters, and the latter in an arc weld made with a hollow electrode filled with pulverized metallic titanium, magnified 400 diameters. These titanium nitride crystals are very hard and angular, and are orange-pink in medium- or high-carbon steel, and yellow when the carbon is low. They are thus easily recognized with the microscope by their color and form.

From this outline of the present knowledge regarding nitrogen in steel, it appears that many of the theoretic-

cal aspects are still to be worked out. The structures, for instance, have not been thoroughly explained, nor the compounds, solubilities and other properties definitely settled. Neither is it clear why the structures change on heat-treatment as they do, since the alloys lack critical points.

The embrittling effect of nitrogen on steel has been definitely established beyond question, but no practical cure for this condition in fusion welds has been proposed so far. In ordinary commercial steel there is yet considerable doubt and difference of opinion as to just what practical importance attaches to the very minute amounts of nitrogen that can be found. Considering all the evidence available, it does not seem proved that the amounts of nitrogen present in commercial steel, except in circumstances so extraordinary as to be negligible in the long run, are of any particular detriment to the quality. There are also differences of opinion in regard to the removal of nitrogen from steel by titanium treatment when melted. Unquestionably, however, a nitride of titanium is formed, and a majority of the evidence supports the view that this nitride tends to separate and rise from the steel. The idiomorphic character of the crystals shows that they are insoluble in the liquid steel. At any rate when present in the form of these crystals, the nitrogen could not have the same embrittling effect as it might have when dissolved as iron nitride in the ferrite.

G. F. C.

RECENT EXPERIMENTS ON NITROGENIZED IRON

Having noted the variety of opinions expressed by previous writers as to the metallographic appearance of nitrogenized iron and the effect of annealing upon the structure of fusion arc welds (see Figs. 3 and 4, also Ruder, *General Electric Review*, vol. 21, p. 941), the following experiments were undertaken to determine the effect of heat treatment, particularly the rate of cooling, upon the microstructure of nitrogenized pure iron.

A $\frac{1}{2}$ -in. swaged bar of pure vacuum-fused electrolytic iron was nitrogenized by heating to 700 deg. C. for about 3 hr. in a stream of pure NH_3 . It was then cut up into five parts, each of which had a structure as shown in Fig. 8.

Piece 1 was then heated to 600 deg. C. for 15 min. and quenched in water (Fig. 9). After examination it was again heated to 600 deg. C. for 15 min. and allowed to cool with the furnace (Fig. 10). The micrographs show that this short heating to 600 deg. was sufficient to cause absorption of the needles by the ferrite and in the quenched sample the nitride needles are largely held in solution. Upon slow cooling from this temperature the nitride does not re-appear as needles but as pearlitic patches (as in Fig. 2) and intergranular material.

Sample 2 was then heated to 700 deg. C. for 15 min. and quenched in water (Figs. 11 and 12), following which it was reheated to 700 deg. C. for 15 min. and slowly cooled. Quenched from this temperature the grains are much larger than when quenched from 600 deg. C. and the only appearance of the presence of nitrogen is at the grain boundaries, which widen and become more distinct upon deeper etching. On slowly cooling the reheated sample, however (Fig. 13), the needles again make their appearance. Apparently a temperature of at least 700 deg. C. with slow cooling is required to show any needles. In this case the nitrogen appears both as needles and widened grain boundaries.

Sample 3 was treated the same as the previous ones, except that in this case the temperature was 800 deg. C.

The results were about the same as when treated at 700 deg. C., except that the grain boundaries are wider and not quite so dark (Fig. 14). On slow cooling the needles reappear as before (Fig. 15). Subsequent reheating and quenching brought back the structure shown in Fig. 14.

Sample 4 was treated in the same manner except that the temperature was 950 deg. C. At this temperature practically all the nitride is absorbed in the ferrite and is retained in solution by quenching, so that the micrographic appearance is practically that of pure ferrite. On slow cooling, the grain is much smaller and the nitride appears as needles and at the grain boundaries. Considerable diffusion of the outside nitride band inward has also taken place. This is significant in view of Strauss' contention that the dark pearlitic areas are due to the presence of carbon introduced by impurities in the ammonia. Inasmuch as these particles do not occur in the original bar as nitrogenized (Fig. 8), but do occur and disappear with heat treatment, it would seem that carbon had nothing to do with their occurrence.

Fig. 18 shows the appearance of the bar when heated to 1,000 deg. C. and slowly cooled. Both needles and widened grain boundaries are shown. Decided grain refinement with rapid diffusion inward of the outside nitride band is also evident.

CONCLUSIONS

In view of these results it seems evident that nitrogen may occur in a variety of forms, depending upon the rate of cooling and the degree of heat applied. The needles now commonly accepted as indicating the presence of nitrogen may not be visible at all, even in highly nitrogenized steel. The same is true of the widened grain boundaries. The presence of carbon does not seem to be necessary to the formation of the dark pearlitic-appearing patches. They are rather a function of the percentage of nitrogen present and the rate of cooling.

To call these needles Neumann lines or slip bands caused by cutting for polishing is erroneous, for if they were the former they should disappear on heating above A_c , which they do not, and if the latter, they should appear in the quenched as well as in the slowly cooled samples. These lines appear rather to be a nitride of iron which is entirely soluble at temperatures above 700 deg. C. in ferrite and retained in solution by quenching but rejected at the boundaries and cleavage planes on slow cooling.

Experiments described in a previous paper (*General Electric Review*, vol. 21, p. 941) show that nitrogen in steel is quite stable and may be driven off only after prolonged heating at a high temperature *in vacuo*, or by passing hydrogen over the sample at about 600 to 700 deg. C.

W. E. R.

Rubber Tires in China

It is reported that the rubber tire industry is getting to be so large in China that manufacturers are talking of starting their own factories in that country. While Peking has less than 1,000 automobiles, there will be many thousands of motor vehicles in operation in the near future.

The typical vehicle of today is the jinrikisha, and rubber tires are being employed. Every 24 hours 50,000 of these jinrikishas pass through the great central gateway of Peking.

Problems Investigated at the Color Laboratory, Bureau of Chemistry

BY H. D. GIBBS

THE Color Laboratory of the Bureau of Chemistry was organized early in 1916, for the purpose of studying colors, their formation and uses. Shortly after its organization Congress appropriated \$50,000 for the first year, and since that time two appropriations of \$75,000 each for the second and third years, and for the fourth year, beginning last July, \$100,000 has been secured to carry on the work, providing for personnel, building and equipment. The immediate object of the work has been to make detailed studies of reactions, processes and apparatus, with a view to assist the development of the American chemical industries, with special reference to the organic preparations that are necessary in the production of dyes and also to carry on studies in the natural agricultural products that have such great value in industry. It has been realized from the start and is being more and more appreciated by American industries that success depends upon the ability to produce compounds at a low cost. To do this the factor of yields is the most important, and detailed studies throwing light upon the mechanism or reactions have been undertaken. In many cases the long and tedious investigations necessary to work of this nature cannot be undertaken by industrial research laboratories where the press of factory problems is very great.

In order to carry on this work an old building at Arlington, Va., was taken over and remodeled so far as possible to suit the need. Various lines of research were started in the meantime in the laboratories of the Bureau of Chemistry. The plant at Arlington is unique in that it combines manufacturing facilities with complete laboratory equipment.

The technical part of the plant is being equipped with an extensive variety of large-scale apparatus. This is to be operated, not for the purpose of manufacturing, but for the purpose of studying manufacturing operations. It is quite possible that where the industries of the country are not able or willing to furnish compounds that are required we will be able to manufacture and supply the demand until the industries are in a position to undertake the work.

PHOTOGRAPHIC SENSITIZING DYES

One investigation has now arrived at this stage of development. I refer to the production of the photosensitizing dyes of the quinoline type. Of these pinaverdol, pinacyanol, or thochrome, dicyanine, and dicyanine A have been successfully synthesized and tested by physicists, astrophysicists and plate manufacturers. A number of plate manufacturers have been very successful in incorporating several of these dyes in photographic gelatine emulsions, and tests of the plates so produced show them very satisfactory and the dyes to be at least equal in performance to the corresponding dyes formerly produced by Meister Lucius and Brünig. The American patents on some of these dyes were formerly owned by the Höchst concern, but are now the property of the Chemical Foundation. The Color Laboratory is prepared to instruct chemists who will undertake the commercial manufacture of these dyes and assist in any way in stimulating the production of

these valuable aids to the physicist and photographic plate manufacturer.

With the exception of the photographic sensitizing dyes, the investigations so far undertaken have been quite general in character and include vapor phase studies in chlorination, oxidation and sulphonation, a study of caustic fusions, a study of the derivatives of cymene, at present a waste product of the sulphite spruce paper industry, and there is also under way in the laboratory at this time a study of the vapor pressure curves of a number of aromatic organic compounds.

Thirty-one papers have been written by the laboratory staff, more than twenty of which have already appeared in print, and many others are in course of preparation. Owing to the demands of the industries for chemists and the interference of the war, the per-



FIG. 1. ELECTRIC TRANSMISSION LINE, 6,600 VOLTS. A VIEW OF NORTH AND WEST SIDES

sonnel of the Color Laboratory has undergone many changes, in fact almost completely changed twice, and our plant has been greatly delayed in construction. For these reasons it has been very difficult to carry research to a conclusion.

I will describe very briefly a few of the investigations that so far have not been published.

VAPOR PHASE CHLORINATION

The chlorination of toluene in the vapor phase, catalyzed by ultra violet light, for the production of benzyl chloride, benzal chloride and benzotrichloride, has been studied. The work to the present has indicated that the extent of the chlorination can be controlled to a considerable extent by the character of the light, the relation between the reacting gases and the temperature. Low-pressure quartz mercury lamps tend to produce mostly benzal chloride, while high-pressure lamps produce more benzotrichloride. G. A. Geiger, A. B. Clark and H. A. Lubs have published some preliminary analytical papers on this work.

VAPOR PHASE OXIDATION AND VAPOR PHASE SULPHONATION

Studies of the vapor phase oxidation of various hydrocarbons and other compounds by means of atmospheric air in the presence of catalysts have shown that toluene can be oxidized to benzaldehyde and benzoic acid, naphthalene to phthalic anhydride and benzoic acid, anthracene to anthraquinone, phenanthrene to phenanthraquinone. Preliminary publications are being prepared by C. Conover, K. P. Monroe and myself.

A number of methods are in practical application for the sulphonation of various compounds. The most common consists in the mixing of sulphuric acid of suitable strength and the compounds to be sulphonated in an iron pot, stirring the mixture rapidly with or without the application of external heat; the Tyrer process,¹ consisting in the passing of the vapors of the substance to be sulphonated through sulphuric acid heated to the desired temperature; the Downs method,² consisting in heating the substance being sulphonated and the sulphuric acid *in vacuo* for the purpose of removing the water and sulphuric acid by distillation; and the Kendall process,³ providing for the addition of the compound to be sulphonated to the molten liquid form of certain acid sulphates or pyrosulphates. All of these are batch processes. The first continuous process is that devised by Dennis⁴ and perfected by Bull,⁵ which has been used for the production of the monosulphonic acid of benzene. It consists in pumping benzene through sulphuric acid and then into water, producing a continuous circulation of the benzene, and the process depends upon the fact that small quantities of benzene monosulphonic acid are dissolved in the benzene and carried to the water, where it is washed out and the benzene re-circulated through the sulphuric acid. Our process differs materially from any of the above in that it is continuous, the products of the reaction are removed very rapidly, as formed, and in that various compounds can be sulphonated successfully at any required temperature.

The sulphonation of various hydrocarbons in the vapor phase with sulphuric acid of varying strengths has been successfully carried out by this process on a small scale.

Benzene can be sulphonated with chamber acid (55 deg. Bé. = 70 per cent). Naphthalene can be made to yield a product containing disulphonic acids of which the 2.7-derivative constitutes about 85 per cent, while the 2.6-derivative makes up the remainder of about 15 per cent. The former furnishes a valuable starting material for the much used H acid. J. A. Ambler, C. E. Senseman and William J. Cotton are preparing preliminary papers on this work.

WAR WORK

During the war the incompleting building at Arlington was loaned to the Nitrate Division of the Ordnance, and the laboratories and almost the entire personnel of the Color Laboratory were engaged in work for the Chemical Department of the Science and Research Division of the Bureau of Aircraft Production. Some of the chemical problems solved for the Air Service were rather interesting, and I will outline a few of them.

Early in the prosecution of the airplane program it became evident that new sources of acetic acid and its derivatives must be developed, since the manufacture of smokeless powder promised to require all of the acetone production in sight. Two entirely new processes employing raw materials not heretofore used for any purpose were developed, the first to produce acetic acid, the second to produce acetone.

Hudson, Harding and La Forge, of the Bureau of Chemistry, very recently devised a method for the

¹U. S. Pat. 1,210,725.

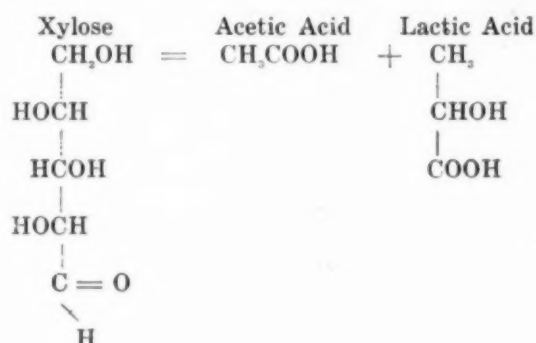
²U. S. Pat. 1,279,295; 1,279,296; 1,301,785.

³U. S. Pat. 1,217,462.

⁴U. S. Pat. 1,211,923; 1,212,612; 1,227,252; 1,228,415; 1,229,593.

⁵U. S. Pat. 1,247,499; also CHEM. & MET. ENG. Sept. 1, 1918, pp. 255-260.

manufacture of xylose on a commercial basis at a very low cost, from such abundant materials as corn cobs and wood, and L. A. Round, also of the Bureau of Chemistry, had isolated an organism that would ferment xylose, with the production of acetic acid. It seemed very desirable that this process should be investigated to determine if it were practicable for commercial application. Substances rich in xylane, such as corn silage, sauerkraut and manure, seemed most likely to contain xylose-fermenting bacteria. It was found that pure cultures could be obtained by fishing from plates and seeding into liquid 2 per cent xylose yeast medium. The fermentation process was found to proceed very nearly quantitatively as represented by the splitting of one molecule of xylose into one molecule of acetic acid and one molecule of lactic acid, according to the equation:



It has been found that the oxygen supply within wide limits has little effect. The process has been successfully carried out on a small scale by grinding corn cobs, hydrolyzing and inoculating the solution so formed, thus reducing the expense of the process in that it is not necessary first to isolate the xylose. An article descriptive of this work, by Fred, Peterson and Davenport, appeared in the September issue of the *Journal of Biological Chemistry*.

ISOPROPYL ALCOHOL AND ACETONE

It has been found that the waste gases of the Burton process for cracking petroleum can be used for the production of isopropyl alcohol and acetone. These gases contain from 8 to 14 per cent of propylene, which can be absorbed in sulphuric acid of the proper strength. This solution, on hydrolysis, gives isopropyl alcohol, and

a continuous catalytic process has been devised for converting isopropyl alcohol into acetone. This consists in passing the vapors of isopropyl alcohol, mixed with atmospheric air, over a catalyst and thus removing two hydrogen atoms from the isopropyl alcohol, the result being acetone. It has been estimated that from 50,000 to 100,000 gal. of acetone can be produced daily by this process if all of the waste gases from the Burton stills were utilized. A paper, by R. R. Williams and myself, descriptive of this work will appear shortly.

THE DISCHARGE OF CLOUDS FROM AIRPLANES

A number of uses for clouds discharged from airplanes were suggested, and the following three that were investigated by R. R. Williams are interesting, only two, however, being of real value:

It was found that signals could be discharged from airplanes in a very satisfactory manner by a series of colored clouds in the form of smoke balls or streamers released at irregular intervals, somewhat in the manner of Morse or Continental codes. For this purpose a solution of volatile dye in a volatile solvent may be discharged into the engine exhaust. The result is a smoke colored according to the dye used. A saturated chloroform solution of Sudan II* gave very satisfactory results. The smoke was cherry red and very clearly visible at an altitude of 5,000 ft. Observers state that they believe it would have been visible at 10,000 ft.

Another possible use for smoke on airplanes is the imitation of a plane in flames. This was fairly satisfactorily demonstrated by spilling 15 lb. of lampblack at a uniform rate from a position near the observer's seat on a plane that was in the meantime maneuvering to imitate loss of control.

Several men connected with the force at Langley Field, who saw this test in operation, without knowledge of its object, were deceived by it and shouted to call attention to the machine on fire.

Color Laboratory,
U. S. Bureau of Chemistry,
Washington, D. C.

School of Optics

There has been established at Paris an optical institute that will work in the interest of the manufacturers of opticians' supplies, according to *Science*; it will not be conducted for commercial profit, but solely for the purpose of advancing optical science and the optical industries for the common welfare. The forms of activity of this new scientific institute will be: (1) a training school of optics; (2) a laboratory of research and experiment, and (3) a professional school for advanced study. The school of optics will train experts in the manufacture of optical goods. C. Fabry, at present professor of general physics at the Faculté des sciences de Marseilles, has been selected as the head of the new institution. Lucien Poincaré, rector of the University of Paris, has evinced an especial interest in the institute and has expressed his intention of requesting a professional chair of optics at the Sorbonne. The laboratories will comprise a research department in which the instructors of the school may conduct their theoretical and practical researches with relation to the various kinds of glass, optical instruments and opticians' accessories, and a department for the study of manufactured products or any matter of importance submitted for examination by the institute. These laboratories will serve likewise for the training of students.

*Sudan II, Schultz (1914), No. 76, xylidine and β -naphthol.



FIG. 2. AN AIRPLANE VIEW OF A PLANE IN PROCESS OF PRODUCING ARTIFICIAL CLOUD

Pumping Acid With Compressed Air

BY JOHN OLIPHANT

Chief Engineer, Pumping Dept., Sullivan Machinery Co.

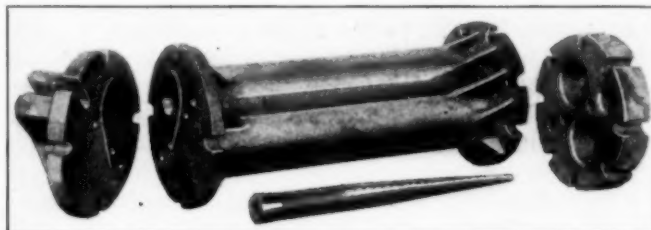
DURING the past two or three years, the use of compressed air for handling, elevating and transferring acids and chemical solutions has been greatly extended, and as the more modern principles of air-lift pumping have been applied to the chemical field, the efficiency and convenience of the system have made rapid strides. The advantages of the air-lift system for handling acid as compared with mechanical pumps or other less modern methods and as demonstrated by actual installations made by the company with which the writer is associated may be enumerated briefly as follows:

Durability—The foot pieces and separator heads may be made of any desired acid-resisting material, such as hard or soft lead, rubber, cast iron or cast steel, "Duriron," etc. There are no moving parts to cause wear, and the free open passage characteristic of this apparatus secures a much longer life than that enjoyed by mechanical pumps.

Flexibility—The normal delivery may be increased as much as 25 per cent or decreased by the same amount with very little change in operating efficiency. Still greater variation may be obtained, although with a sacrifice in efficiency. This is accomplished by the movement of a valve controlling the air supply.

Principles of the Air Lift—The principle of the air lift is to lighten the column of water in the suction pipe with air so that the weight per sq.in. of the suction column mixed with air at the air jet is less than the submergence head. For a low percentage of submergence, more air must be used than with a high percentage of submergence for the same lift in order to keep the weight of the suction column below the submergence head. However, with the low submergence, a lower pressure is required, so that the power is theoretically equal. The question of velocity and air expansion, in a low lift with a low submergence, is one that requires especially careful designing. With acids, however, the high specific gravity and high temperature of

always mean 40 per cent lift, 35 per cent submergence 65 per cent lift. The percentage of submergence may vary with the lift. In pumping water a higher per cent of submergence is desirable for low lift and the percentage of submergence may be decreased as the lift increases up to certain points. The air-lift is usually thought of as suitable only for deep wells, but with improved apparatus and careful engineering, excellent results in overall efficiency are being shown on relatively low submergences. In cases not permitting wells or



ACID FOOT PIECE AND MIXING TUBE

holes to be drilled to secure the necessary submergence, the compound lift may be employed. This involves lifting the acid or other fluids to a sufficient elevation to give adequate submergence for the final lift.

Central Power Supply—The air-lift foot pieces or jets may be located at any desired point in the plant and operated by air from a central station with little loss in friction and no loss such as that of condensation or drop in power as is experienced with steam or electric transmission. The compressor is under the eye of the operating engineer, and attendance of mechanics at the point of use is unnecessary, as would be the case for repair or adjustment of mechanical pumps. The tower-men readily control the volume pumped from each unit as well as the starting or stopping of it by means of air valves.

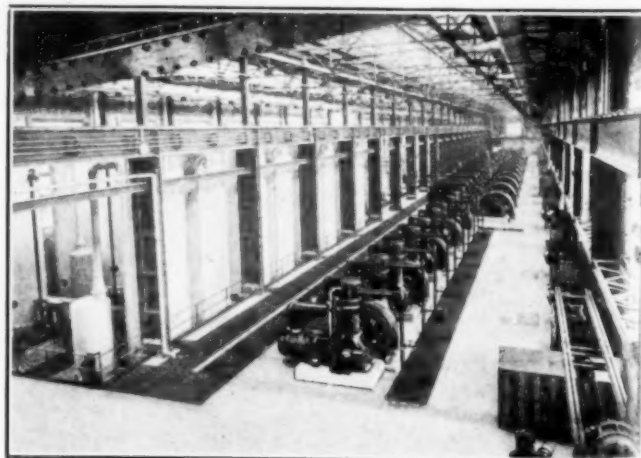
Efficiency—The equipment and system employed by this company in its air-lift apparatus secure the thorough mixing of the air and the fluid to be raised by means of a large number of fine jets of air, discharging into a thin sheet of the fluid. With this equipment and with careful installation, the pump efficiency averages from 30 to 35 per cent. While this may be exceeded by mechanical pumps under test conditions, it is found, under actual practice, that the air-lift is more efficient and maintains its efficiency at a higher point, after a short period of operation. This is on account of the



SEPARATOR HEAD

the liquids to be handled give better results with low percentage of submergence than is secured with water.

Submergence—Submergence is a term used to indicate a head into the intake of an air lift pump and controls the pressure at which the pump operates. It is expressed in feet to the point above the foot piece to which the liquid would rise in the suction pipe without the aid of the air. The submergence added to the lift is called 100 per cent and the percentage of submergence is always a complement of the percentage of lift. For instance, 60 per cent submergence would



SERVICE COMPRESSORS, LIQUID AIR BUILDING
PLANT NO. 2



ACID LIFTS AND SEPARATING HEADS IN ABSORPTION BUILDING, PLANT NO. 2

detrimental effect of the acid on mechanically operated pumps of either the centrifugal or plunger type; while at the same time the cost of repairs and attendance is eliminated.

Safety—The separator head furnished by this company performs another service, namely, that of conveying away the fumes or air integrated with the acid, so that the employees are not exposed to this dangerous element. The fumes can thus be carried into the tower or to any other point desired.

Design—A word of caution may be in order in reference to air-lift installations. While as described above, when proper equipment is selected and the installation made by experienced engineers, the results are superior to those obtained by other means, seemingly unimportant differences in pipe areas and in the handling of the air many times make a considerable difference in the effectiveness of the installation.

NITRATE PLANT NO. 1

An example of this compound lift is found at the United States Nitrate Plant No. 1, Sheffield, Ala. The problem consisted in raising the acids through a tank 60 ft. above the surface from a sump or selecting pit 20 ft. in depth. Two rows of Sullivan Compound Jets and Pumps were installed on either side of a steel tower containing the tank. The acid was delivered at a point a foot or two above the surface and the drop into the pit gave a submergence of 20 ft. Using a submergence of 50 per cent, a discharge was obtained at a point 20 ft. above the surface. The air and acid were separated in a separator tank at that point, the acid being then carried back to the second foot piece, at which a submergence of 40 ft. was obtained for the second lift. Figuring the submergence at 50 per cent, the acid

was carried readily to the final elevation 60 ft. above the surface.

While this arrangement requires more air than a single lift, a lower pressure is sufficient. The actual power needed is no greater than that necessary for a single lift of 60 ft. with 50 per cent submergence.

Compressed air at 40 lb. pressure for the lifts described above is supplied from the central power house, where two Sullivan Corliss Tandem Compound Duplex Air Compressors, type WC, are situated. These compressors supply 1,500 cu.ft. of free air per min. each.

The purpose of handling the liquid at both No. 1 and No. 2 plants, the latter to be described later, was to convert water into nitric acid by bringing it in contact with a nitrous gas. At one end of the absorption tower building the solution was practically water, viz., a 5 per cent solution, and was pumped up into the tank at the top of the absorption tower building, where it absorbed a certain amount of acid from the gas with which it came in contact and was then discharged into the next well and thus pumped back and forth, until after passing through several stages (six in Plant No. 1) it left the building at 50 per cent strength.

NITRATE PLANT NO. 2

The problem in Nitrate Plant No. 2 was to lift approximately 50 gal. of acid per min. with each lift from the bottom to the top of the tower. The actual lift to be performed was approximately 70 ft. As the tower bottom was only about 3 ft. above the ground level, 12-in. iron casings were sunk to a depth of 100 ft. in



AIR LIFT INSTALLATION AND ABSORPTION TOWERS, PLANT NO. 1. SEPARATOR HEADS IN CENTER



AIR-END VIEW OF THE SIX TWIN ANGLE-COMPOUND COMPRESSORS, PLANT NO. 2

the ground below the building. Pipes 3 in. in diameter carried the acid from the foot of the tower to the top of the wells, and then down to the Sullivan foot pieces at the bottom of the wells. At this point air was introduced and the air-lift took effect through a 3-in. education pipe, lifting the acid to the top of the tower. These pipes were made principally of aluminum and Duriron and the nitric acid, as stated above, varied from 5 to 50 per cent strength. There were 120 of these wells sunk, some on each side of the steel towers.

At the top of the tower the air was separated from the acid by use of a simple separating head designed by the Sullivan Machinery Co. and made of Duriron. The acid was drained out over and into the tower through distributors, and the air which had been used in lifting the acid was carried out of the building through main headers, so that the fumes would not injure the workmen. By this method relatively low pressure could be used and perfect regulation of the pumping was secured. The diameter of the air supply pipes leading to the bottom of the well was 1½ in. and these were made of aluminum. Air valves as well as the valves on the acid pipe line were used for regulating the flow of the acid and for the starting and stopping of each individual lift. The type of nozzle or foot-piece used on both Plant No. 2 and No. 1 is illustrated in the accompanying photograph. The air was mixed with the acid by a large number of jets which discharged into a sheet of the acid, securing an almost perfect emulsion.

AIR INSTALLATION, PLANT NO. 2

Compressed air at 100 lb. pressure for the acid lift at No. 2 plant was supplied by six WN-4 Twin-Angle Compound Compressors with a capacity of 2,600 cu.ft. per min. This plant is shown in the accompanying illustration.

These compressors are equipped with plate valves of the end-rolling finger pattern and are operated by direct-connected electric motors mounted on the crank shaft of each compressor.

We are indebted to the officials of the Ordnance Department, U. S. Army, for the permission to use these photographs and data, which were supplied by the Chemical Construction Co., engineer and subcontractor for the chemical installations at Plants Nos. 1 and 2; to the Duriron Castings Co., of Dayton, Ohio, by whom the air lift pumps and separators, designed by Sullivan pneumatic pumping engineers, were made up, and to the American Cyanamid Corporation.

New Ceramic Research Station at Rutgers College

By E. C. MILLEN

WITH the ratification of a bill by the New Jersey State Senate, Feb. 2, covering an appropriation of \$100,000 for the erection of a new ceramic building at Rutgers College, New Brunswick, there is every indication that this measure will be approved by the State Assembly, receive the Governor's signature and so become a law. This fund will give New Jersey what it has long needed—a first-class ceramic institution for instruction and research work.

The movement for this new building has been under way for the past few months, receiving the united support of those prominent in the clay-working and affiliated industries throughout the state. The bill referred to provides for the construction of a building, together with the proper machinery, apparatus and equipment, at an expense of 100,000, to be paid by the state, and an additional appropriation of \$12,000 annually, beginning in 1921, for salaries, supplies, etc.

CERAMIC INDUSTRIES IN NEW JERSEY

In bringing forward proof of the necessity for this new building, it is pointed out that in the ceramic industries New Jersey is second in importance of all the states, being exceeded only by the State of Ohio. The clay deposits of the state are the most important on the Atlantic seaboard, while the local plastic clay resources rank first among those of the entire country—for firebrick and refractory manufacture they are unsurpassed. There are about 18,000 persons engaged in the industry in New Jersey at the present time and in this connection, recent statistics compiled by the Bureau of Industrial Statistics, State Department of Labor, are of particular interest in showing the number of plants, capital invested and value of production. These, computed in 1918, are:

	Number of Plants	Capital Invested	Annual Value, Products
Brick and terra cotta	68	\$24,495,287	\$15,501,229
Potteries	56	13,577,633	12,948,702
Glass plants	42	10,057,375	11,021,834
Tile	11	1,274,147	1,261,150
Lime and cement	11	12,038,834	4,521,529
Clay mines	39	1,035,703	790,796
Total	227	\$62,478,979	\$46,045,240

To bring these figures up to date, it is estimated that the capital invested is over \$65,000,000 at this time, and the annual value of production close to \$50,000,000.

The present ceramic building at Rutgers College is small in comparison with the three other recognized schools of this character in the country, which are at the Ohio State University, University of Illinois and Alfred University.

PLANS FOR RESEARCH

At the new building in New Jersey, it is proposed to have broad facilities for research work in the solution of everyday problems arising in the industry, assisting state manufacturers in all phases of the industry in their work. It is estimated that this department will be self-supporting in a short time. The departments for instruction will be of modern and efficient status, providing everything necessary in this line. The work, as heretofore, will be under the direction of Prof. George H. Brown.

Theoretical Study of Nitrogen Fixation by the Electric Arc—III

Chemical Dynamics of the Nitrogen-Oxygen Reactions at the Temperature of the Arc and During Cooling—Multiple Arcs With Intermediate Cooling—Speculation on Cooling of the Arc by Adiabatic Expansion and by Molecular Diffusion*

By CHARLES P. STEINMETZ

EXTREMELY rapid cooling of the gases from the arc stream thus appears essential to save the NO produced by the arc. This is usually done by mixing the arc gases with a mass of relatively cool air, that is, passing only a part of the air through the arc. Since, however, the thermal equilibrium concentration of NO in air is not very high even at arc temperatures and a part thereof is lost by dissociation, further reduction of concentration by the admixture of cold air results in a very low concentration, 1 to 1½ per cent. As the result thereof, a very extensive NO absorption system is required, so that it is claimed that most of the cost of both installation and operation is due to the absorption system.

This makes it of interest to investigate whether higher concentrations could be produced by passing the air successively through a number of arcs with intermediate cooling. That is, a part of the air passes through the arc and then mixes with the rest for rapid cooling to the temperature where NO has become relatively stable; then the gas mixture is cooled again, a part passed through the next arc and mixed with the rest for rapid cooling, etc.

By this procedure, the NO content of that part of the gas mixture coming from the arc which passes through the next arc is lost, and thus, with increasing number of successive arcs, the efficiency decreases while the concentration increases.

As an n fold increase of concentration would reduce the absorption plant to $\frac{1}{n}$ or less, it is a commercial question how far the sacrifice of efficiency would be justified by an increase of concentration.

Assuming that the part q of the air is passed through the arc, and then immediately mixed with the remaining part $(1 - q)$ of the air for effective cooling, the gas mixture then is cooled and the part q passed through the second arc, etc.

Let T_1 = temperature of the gas mixture before coming to the arc, and T_2 the temperature of the gas mixture after the part q has passed through the arc. Let T_a = temperature of the arc, T_o = initial air temperature and T_c = temperature of the cooling surfaces (water or steam pipes, etc.) and s = cooling coefficient.

Let a_o = residual NO concentration of the arc gases, that is, that part of the NO concentration produced by the arc which is not dissociated before cooling. Let a_1 and a_2 be the NO concentration of the gas mixture before and after passing through the arc. Therefore, of the gas mixture of temperature T_1 , and concentration a_1 , the part q passes through the arc, and there

acquires temperature T_a and concentration a_o , then mixes with the rest $(1 - q)$ of the gas mixture and this mixture thereby acquires the temperature

$$T_2 = (1 - q)T_1 + qT_a = T_1 + q(T_a - T_1) \quad (65)$$

and the concentration

$$a_2 = (1 - q)a_1 + qa_o = a_1 + q(a_o - a_1) \quad (66)$$

Then the gas mixture, passing over the cooler of temperature T_c , cools to the temperature

$$T_1' = T_2 - s(T_2 - T_c) \quad (67)$$

and at this temperature passes to the next arc at a concentration:

$$a_1' = a_2$$

For the first arc, it is:

$$a_1 = 0$$

$$T_1 = T_o$$

Thus, after passing through n successive arcs, the NO concentration is

$$\begin{aligned} a_n &= qa_o + (1 - q)[qa_o + (1 - q)] \\ &\quad [qa_o + (1 - q)] \dots + qa_o] \\ &= qa_o[1 + (1 - q) + (1 - q)^2 \\ &\quad + \dots + (1 - q)^{n-1}] \\ a_n &= a_o[1 - (1 - q)^n] \end{aligned} \quad (68)$$

The temperature reaches constant final value where the cooling from T_1 to T_1' is the same as the increase by the arc from T_1 to T_2 , and thus $T_1' = T_2$. Substituting this into (67) and (65) gives the two equations for T_1 and T_2 , the temperature of the gas mixture before and after passing the arc:

$$T_1 = T_2 - s(T_2 - T_c)$$

$$T_2 = (1 - q)T_1 + qT_a$$

These give:

$$T_1 = \frac{q(1 - s)T_a + sT_c}{1 - (1 - q)(1 - s)} = \frac{q(1 - s)T_a + sT_c}{q + s - qs} \quad (69)$$

$$T_2 = \frac{qT_a + s(1 - q)T_c}{1 - (1 - q)(1 - s)} = \frac{qT_a + s(1 - q)T_c}{q + s - qs} \quad (70)$$

As one arc gives the concentration:

$$a = qa_o \quad (71)$$

n arcs, if they have the same joint efficiency, should give the concentration:

$$na = nqa_o \quad (72)$$

and as, by (68), they give the concentration

$$a_n = a_o[1 - (1 - q)^n]$$

the efficiency of n successive arcs, compared with that of a single arc, is

$$n = \frac{a_n}{na} = \frac{1 - (1 - q)^n}{nq} \quad (73)$$

but the concentration is increased from a to a_n , that is, by the ratio

$$\log_{10} = \frac{a_n}{a} = \frac{1 - (1 - q)^n}{q} \quad (74)$$

As an instance let the arc temperature be assumed as $T_a = 3600$ deg. abs., and the temperature of the cooler as $T_c = 400$ deg. abs. At 3600 deg. abs. the

*For Parts I and II see CHEM. & MET. ENG., vol. 22, Nos. 7 and 8, Feb. 18 and 25, 1920, pp. 299 and 353.

equilibrium concentration is 6.15 per cent, but assuming a rate of cooling, by admixture, of $b = 10^7$ deg. per sec., the residual concentration of the arc gases is reduced to $a_o = 3.75$ per cent.

Assuming a cooling coefficient $s = 0.5$, and assuming $T_2 = 1400$ deg. abs. as the highest temperature at which the dissociation is still negligible, we get by substituting into (6):

$$1400 = \frac{3600q + 200(1-q)}{1 - 0.5(1-q)} = \frac{400 + 6800q}{1+q}$$

Thus:

$$q = \frac{1}{5.4} = 0.185$$

This gives by (69):

$$T_1 = 900 \text{ deg. abs.}$$

In Table IX are given, for 12 successive arcs, the temperature, T_1 and T_2 , before and after passing through each arc; the NO concentration in per cent and relative, and the efficiency ratio n . As seen, after 4 to 5 arcs, the temperatures have practically reached their maximum values. The same are plotted in Fig. 9.

Table X gives the same quantities, with the air mixture constant q chosen so that not the final temperature, but the temperature after passing through 1, or through 2 or 3 arcs, has reached the chosen temperature limit $T_2 = 1400$. On Fig. 9 these values are plotted as circles, three-cornered and four-cornered stars, for the same nq .

The larger the number of successive arcs, n , the smaller can be the air quantity q which passes the arc,

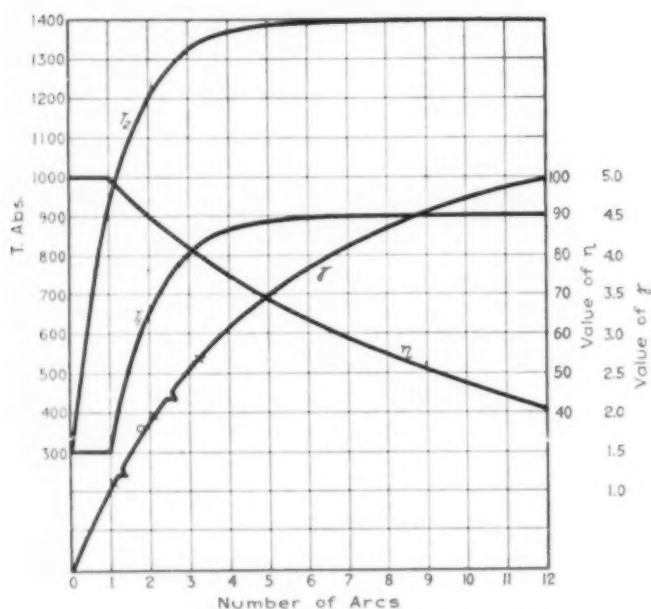


FIG. 9. MULTIPLE ARC NITRIFICATION

and the cooling coefficient s , to give the same concentration and efficiency. It is of interest then to consider the limiting values of a very large number of successive arcs, if acting upon a very small part of the air only, with very little intermediate cooling.

Substituting thus for n , q and s the values pn , $\frac{q}{p}$ and $\frac{s}{p}$, and then making $\lim. p = \infty$, gives the final limit approached by the use of many arcs.

Equation (68) then becomes:

$$a_n = a_o \left[1 - \left(1 - \frac{q}{p} \right)^{pn} \right]$$

and for $p = \infty$, this becomes:

$$a_n = a_o (1 - e^{-qn}) \quad (75)$$

For comparison are added in Table IX the values of a taken from the exponential limit equation (75) and denoted by a .

From (70) follows:

$$q = \frac{s(T_2 - T_1)}{T_1 - T_2 + s(T_2 - T_1)} = \frac{1}{1 + \frac{T_1 - T_2}{s(T_2 - T_1)}} \quad (76)$$

assuming then:

$$T_1 = 3600; T_2 = 1400; T_0 = 400, (12) \text{ gives:}$$

$$q = \frac{1}{1 + \frac{2.2}{s}} \quad (77)$$

substituting in (68) then gives:

$$\frac{a_n}{a_o} = 1 - \left[\frac{1}{1 + \frac{s(T_2 - T_1)}{T_1 - T_2}} \right]^n = 1 - \frac{1}{\left(1 + \frac{s}{2.2} \right)^n} \quad (78)$$

assuming then the desired relative concentration, as for instance:

$$b = \frac{a_n}{a_o} = \frac{2}{3}$$

(78) gives:

$$n = \frac{\log_{10} \frac{1}{1-b}}{\log_{10} 1 + \frac{s(T_2 - T_1)}{T_1 - T_2}} = \frac{0.477}{\log_{10} 1 + \frac{s}{2.2}} \quad (79)$$

The relative efficiency is:

$$n = \frac{a_n}{nqa_o} \quad (80)$$

nq represents the part of the air which is exposed to the arc, and $nq = \text{const.}$, thus would represent constant expenditure of electric energy, assuming that the same size of arcs is used.

TABLE IX. MULTIPLE ARCS

$$T_0 = 300; T_1 = 3600; T_2 = 400; s = 0.5; b = 10^7$$

$$q = 0.185$$

No. of Arcs	Temp. of Gas Mixture Before Passing Arc	Temp. of Gas Mixture After Passing Arc	NO Concentration Per Cent	Relative	Efficiency
n	T_1	T_2	a	y	η
1	300	910	0.694	1.00	1.00
2	655	1200	1.260	1.815	0.907
3	800	1320	1.733	2.50	0.833
4	860	1370	2.106	3.025	0.756
5	885	1390	2.410	3.46	0.692
6	895	1395	2.670	3.84	0.640
7	898	1398	2.870	4.13	0.590
8	900	1400	3.034	4.37	0.546
9	900	1400	3.167	4.55	0.506
10	900	1400	3.278	4.72	0.472
11	900	1400	3.366	4.84	0.440
12	900	1400	3.437	4.95	0.412

TABLE X. MULTIPLE ARC

$$T_0 = 300; T_1 = 3600; T_2 = 400; T_3 = 1400;$$

$$s = 0.5; b = 10^7$$

n	q	T_1	T_2	a	y	η
1	0.33	300	1400	1.250	1.00	1.00
1	0.232	300	1065	0.870	1.00	1.00
2	.....	735	1400	1.540	1.77	0.885
1	0.203	300	970	0.763	1.00	1.00
2	.....	685	1280	1.372	1.80	0.90
3	.....	840	1400	1.851	2.43	0.81

The investigation of a_n , n , etc., at constant nq thus represents the effect of the arrangement of the arcs, or arc furnaces, in series or in multiple.

Table XI then gives, with the cooling constant s as parameter, and for the same values of $T_1 = 3600$, $T_2 = 1400$, $T_3 = 400$, $a_o = 3.75$ per cent, the values of q , n , nq , for $b = \frac{2}{3}$, that is, the final concentration $a_n = 2.5$ per cent NO.

TABLE XI. MULTIPLE ARCS
 $T_a = 3600; T_i = 1400; T_c = 400; a_0 = 3.75; f = \frac{1}{2}$

	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$q =$	0.0222	0.0435	0.0833	0.120	0.154	0.185	0.215	0.241	0.267	0.290	0.313
$nq =$	49.7	25.7	13.8	8.6	6.6	5.4	4.6	4.0	3.5	3.2	3.0
$\eta =$	1.10	1.12	1.15	1.03	1.01	0.99	0.98	0.96	0.945	0.935	0.93
$\eta =$	0.62	0.60	0.58	0.64	0.66	0.67	0.68	0.695	0.705	0.71	0.72

As seen from this table, which is plotted in Fig. 10, the efficiency is best with the use of as small number of arcs in series as feasible. Thus, with four arcs in series, we get a concentration of 2.5 per cent at $q = 0.24$, and an efficiency of about 70 per cent. Thus, to double the NO concentration in the arc gases from the average of the single arc furnaces of 1.25 per cent to 2.5 per cent would require series connection of four furnaces, at a sacrifice of 30 per cent of output.

If then the cost (operation plus interest on the investment) of the absorption plant is 70 per cent, that of the furnace (including power, etc.) is 30 per cent, as has been stated, series connection of four arcs would give a reduction of cost of 35 per cent in the absorp-

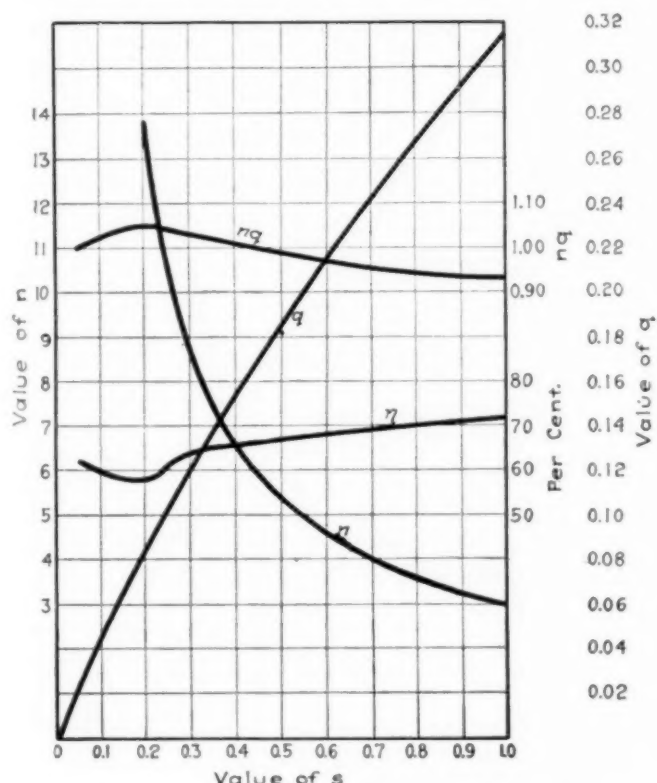


FIG. 10. MULTIPLE ARC NITRIFICATION

tion plant but an increase of 13 per cent in the furnace plant, thus a resultant saving of 22 per cent in the cost, assuming the same type of furnace and absorption system.

As furnaces are more quickly built than absorption systems, with the present plants it would permit in emergencies to double the capacity, within a short time, by commandeering more power—if these theoretical reasons are verified by experience.

SPECULATION ON COOLING OF ARC BY ADIABATIC EXPANSION AND BY MOLECULAR DIFFUSION

When establishing an arc in air, the air in the path of the arc stream is raised to arc temperature, say 4000 deg. abs., and thereby expands in volume. If the arc is formed slowly, or moves slowly through the air, the

air may expand and thereby be set in motion during its heating by the arc, so that the pressure in the arc stream remains constant, and the temperature rise occurs at constant pressure. If, however, the arc is established with extreme suddenness, the air would be heated to arc temperature before it had time to increase in volume by expansion, as a finite time is necessary to set the air in motion. In this case, the heating of the air in the arc stream would occur at constant volume, and the pressure in the arc stream would rise proportional to the temperature rise.¹ This would require materially less heat energy. The air would then expand and thereby drop in temperature by adiabatic expansion or, if the arc persists, additional heat energy will be required to maintain the arc temperature. In either case, the air, while being heated by the arc stream, is set in motion in expanding, and then, after falling again to atmospheric pressure, would continue to move, over-expand to a pressure below atmosphere, with corresponding drop of temperature, until the atmospheric pressure stops the further expansion, and the gas contracts again.

Probably, with the rapidly moving or rapidly started interrupted arcs of nitrogen furnaces, the actual condition is somewhere intermediate between constant pressure and constant volume heating.

As the cooling of the air in the arc stream by the expansion and over-expansion discussed above may lower the temperature down to or near the values where NO is relatively stable, it may be a factor in saving a large part of the NO concentration corresponding to the arc temperature equilibrium, and this would depend on the diameter, that is, the current of the arc, and the manner of its starting, moving, etc., so that the possible magnitude of the effect needs considering.

For this purpose it obviously will be sufficient to consider the air as an ideal gas, and apply the equations pertaining to such.

THERMODYNAMIC EQUATIONS OF AIR AS IDEAL GAS

The general equation is:

$$pv = \frac{r}{M} T = RT \quad (81)$$

where:

p = pressure, kg. per sq.m.

v = volume, cu.m. per kg.

T = abs. temperature.

M = molecular weight, = 29

r = gas constant = 845

R = 29.2

The adiabatic equation is:

$$pv^a = \text{const.} \quad (82)$$

where:

a = adiabatic constant,

= 1.4 for air.

From (1) and (2) follow, for adiabatic expansion or compression between the limits p_0, v_0, T_0 and p, v, T :

¹In agreement wherewith would be the higher voltage required by a transient arc: the arc voltage rises with the pressure.

$$\begin{aligned}\frac{p}{p_0} &= \left(\frac{v_0}{v}\right)^a = \left(\frac{T}{T_0}\right)^{\frac{a}{a-1}} \\ \frac{v}{v_0} &= \left(\frac{p_0}{p}\right)^{\frac{1}{a}} = \left(\frac{T_0}{T}\right)^{\frac{1}{a-1}} \\ \frac{T}{T_0} &= \left(\frac{p}{p_0}\right)^{\frac{a-1}{a}} = \left(\frac{v_0}{v}\right)^{a-1}\end{aligned}\quad (83)$$

The adiabatic expansion energy is, when expanding or compressing adiabatically between the limits p , v , T , and p_0 , v_0 , T_0 ; p_0 , v_0 , T_0 being one point of the adiabatic curve:

$$\begin{aligned}E &= \int_1^2 p dv \\ &= \frac{R}{a-1} (T_1 - T_2) \\ &= \frac{p_0 v_0}{a-1} \left[\left(\frac{v_0}{v_1}\right)^{a-1} - \left(\frac{v_0}{v_2}\right)^{a-1} \right] = \frac{RT_0}{a-1} \left[\left(\frac{v_0}{v_1}\right)^{a-1} - \left(\frac{v_0}{v_2}\right)^{a-1} \right] \\ &= \frac{p_0 v_0}{a-1} \left[\left(\frac{p_1}{p_0}\right)^{\frac{a-1}{a}} - \left(\frac{p_2}{p_0}\right)^{\frac{a-1}{a}} \right] = \frac{RT_0}{a-1} \left[\left(\frac{p_1}{p_0}\right)^{\frac{a-1}{a}} - \left(\frac{p_2}{p_0}\right)^{\frac{a-1}{a}} \right] \\ &= \frac{RT_1}{a-1} \left[1 - \left(\frac{v_2}{v_1}\right)^{a-1} \right] = \frac{RT_2}{a-1} \left[\left(\frac{v_2}{v_1}\right)^{a-1} - 1 \right] \\ &= \frac{RT_1}{a-1} \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{a-1}{a}} \right] = \frac{RT_2}{a-1} \left[\left(\frac{p_1}{p_2}\right)^{\frac{a-1}{a}} - 1 \right]\end{aligned}\quad (84)$$

If the energy of adiabatic expansion is converted into velocity, the kinetic energy of the velocity s being, per unit weight or kg.

$$E = \frac{s^2}{2g} \quad (85)$$

where

$$g = 9.83$$

= acceleration of gravity,

it follows from (85) and (84):

$$s = \sqrt{2gE} = \sqrt{\frac{2gR}{a-1} (T_1 - T_2)} \quad (86)$$

= $37.7 \sqrt{T_1 - T_2}$ meter seconds for air, as the velocity of adiabatic expansion.

At constant pressure p' the expansion energy of unit weight (kg.) of gas between volumes v_1 and v_2 is:

$$E = p' (v_2 - v_1) \quad (87)$$

Applying now the gas equations to the thermodynamic phenomena occurring in a suddenly started and suddenly interrupted arc stream:

Let a gas cylinder of diameter d_1 of pressure p_1 and temperature T_1 be suddenly heated to temperature T_2 , at constant volume: $v_2 = v_1$, by an arc of stream diameter d_1 .

The pressure of the gas stream is thereby raised to: (81)

$$p_2 = p_1 \frac{T_2}{T_1} \quad (88)$$

The gas then expands adiabatically back to the pressure p_1 of the surrounding atmosphere and thereby increases in volume and drops in temperature to: (83)

$$\begin{aligned}v_2 &= v_1 \left(\frac{p_2}{p_1}\right)^{\frac{1}{a}} \\ T_2 &= T_1 \left(\frac{p_1}{p_2}\right)^{\frac{a-1}{a}}\end{aligned}\quad (89)$$

and the diameter of the gas stream thereby increases to:

$$d_2 = d_1 \sqrt{\frac{v_2}{v_1}} = d_1 \left(\frac{p_2}{p_1}\right)^{\frac{1}{2a}} \quad (90)$$

In expanding then adiabatically, from p_2 , $v_2 = v_1$, T_2 , to $p_3 = p_1$, v_3 , T_3 , the gas gives the energy: (84)

$$E_o = \frac{R}{a-1} (T_2 - T_3) \quad (84)$$

Of this, the energy (87):

$$E' = p_1 (v_3 - v_1) = RT_1 \left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{a}} - 1 \right] = RT_1 \left[\left(\frac{T_2}{T_1}\right)^{\frac{1}{a-1}} - 1 \right] \quad (91)$$

is consumed in pushing away the surrounding atmosphere, thus leaving the energy:

$$E = E_o - E'$$

This energy E , doing no external work, becomes kinetic, and the gas thus assumes the velocity.

$$s = \sqrt{gE} = \sqrt{g(E_o - E')}$$

When the expanding air has again reached atmospheric pressure p_1 , at temperature T_3 , it thus has the velocity s , and continues to move with this velocity radially outward, thus over-expands, until its kinetic energy has been spent in pushing away the surrounding atmosphere of pressure p_1 , at pressure p_1 , volume v_4 , and temperature T_4 .

At this point, the work done in pushing away the surrounding atmosphere: (81) and (83)

$$E'' = p_1 (v_4 - v_1) = RT_1 \left[\frac{v_4}{v_1} - 1 \right] = RT_1 \left[\left(\frac{T_2}{T_4}\right)^{\frac{1}{a-1}} - 1 \right] \quad (92)$$

has become equal to the total energy of expansion:

$$E_{oo} = \frac{R}{a-1} (T_2 - T_4)$$

Thus,

$$T_1 \left[\left(\frac{T_2}{T_4}\right)^{\frac{1}{a-1}} - 1 \right] = \frac{T_2 - T_4}{a-1} \quad (93)$$

This gives the temperature T_4 , and herefrom the pressure p_4 and the volume v_4 , and the diameter d_4 of the gas column.

The average velocity of expansion from volume v_1 to v_3 to v_4 is (assuming parabolic law):

$$s_o = \frac{2}{3}s$$

TABLE XII. ADIABATIC EXPANSION OF ARC

$p_1 = 10_4 = 1$ kg. sq.cm.	$E_o = 140,200$ kg.m.
$T_1 = 400$ deg. abs.	$E_1 = 48,000$ kg.m.
$v_1 = \frac{RT_1}{p_1} = 1.168$ cu.m.	$E = 92,200$ kg.m.
$T_2 = 4000$ deg. abs.	$s = 952$ m.sec.
$p_2 = 10$ kg. sq.cm.	$s_o = 635$ m.sec.
$v_2 = v_1$	$T_3 = 1255$ deg. abs.
$T_3 = \frac{T_2}{1.93} = 2080$ deg. abs.	$v_4 = \frac{p_2}{57.6} = 0.184$ kg.sq.cm.
$p_3 = p_1 = 1$ kg. sq.cm.	$r_4 = 18.1$ $r_1 = 21.1$ cu.m.
$v_3 = 5.18$ $v_1 = 5.97$ cu.m.	
$a_o = 7.95$ per cent at $T_2 = 4000$ deg. abs.	
$d_1 = d_2 = 0.1$	0.2 0.5 1.0 2.0 5.0 10.0 cm.
$d_3 = 2.276$ $d_1 = 0.2276$	0.455 1.138 2.276 4.55 11.38 22.76 cm.
$d_4 = 4.25$ $d_1 = 0.425$	0.85 2.13 4.25 8.5 21.3 42.5 cm.
$t_3 = 1.0$	2.0 5.0 10.0 20.0 50.0 100.0 micro sec.
$t_4 = 1.55$	3.1 7.8 15.5 31.0 78.0 155.0 micro sec.
$b_3 = 19.2$	9.6 3.84 1.92 0.96 0.384 0.192 $\times 10^6$
$b_4 = 5.4$	2.7 1.08 0.54 0.27 0.108 0.054 $\times 10^6$
$\log_{10} b_3 = 9.283$	8.982 8.584 8.283 7.982 7.584 7.283
$a = 5.30$	5.05 4.86 4.63 4.39 4.13 3.94 % NO
$\frac{a}{a_o} = 66.7$	63.5 61.1 58.2 55.2 51.8 49.6 per cent

The average distance traveled by the expanding gas of the cylindrical column is:

$$\text{From } \frac{d_1}{3} \text{ to } \frac{d_3}{3} \text{ to } \frac{d_4}{3}$$

$$\text{or } \frac{d_3 - d_1}{3} \text{ and } \frac{d_4 - d_3}{3}$$

At average velocity s_0 , this gives the time, during which the gas expands:

$$t_3 = \frac{d_3 - d_1}{2s} \quad (94)$$

$$t_4 = \frac{d_4 - d_3}{2s}$$

and as the temperature drop during the two periods of gas travel is:

$$T_2 - T_3 \text{ and } T_3 - T_4$$

it gives the average rate of cooling, or the cooling constants:

$$b_3 = \frac{T_2 - T_3}{t_3} = \frac{2s(T_2 - T_3)}{d_3 - d_1} \quad (95)$$

$$b_4 = \frac{T_3 - T_4}{t_4} = \frac{2s(T_3 - T_4)}{d_4 - d_3}$$

and from the cooling constants b follows, by the previous considerations, the residual NO concentration a , which escapes dissociation.

As an instance may be considered, for arc temperature $T_2 = 4000$, and initial air temperature $T_1 = 400$ at atmospheric pressure $p_1 = 10^4 = 1$ kg. per sq.cm. (which is about the average atmospheric pressure), the values corresponding to various arc diameters from $d_0 = 0.1$ to $d_4 = 10$ cm., for the values:

$$d_1 = 0.1 \ 0.2 \ 0.5 \ 1 \ 2 \ 5 \ 10 \text{ cm.}$$

The values are recorded in Table XII, showing a decreasing recovery $\frac{a}{a_0}$ with increasing diameter of the arc stream.

Substituting in (86)

$$T_2 = 0$$

gives:

$$s_0 = \sqrt{\frac{2gR}{a-1}} T$$

$$= 37.7\sqrt{T} \quad (96)$$

as the limiting velocity of expansion from temperature T into a perfect vacuum, representing the conditions where all the heat energy of the molecules is converted into the kinetic energy of motion, and this velocity s then represents the molecular energy of the heat energy.

For the arc temperature

$$T = 4000$$

This gives:

$$s_0 = 2380 \text{ m.sec.}$$

This would then be the velocity, with which the molecule of the hot gas diffuses into the surrounding cold air.

As the molecular velocities are in all directions, the component of the velocity in the radial direction is only

$$s_1 = \frac{2}{\pi} s_0 = 1510 \text{ m.sec.}$$

With an arc diameter of $d_1 = 1$ cm., thus an average distance of <0.5 cm. to travel, this would give a time of travel of $t = <3.3$ microsec. At a surrounding air temperature of 400 deg. abs., thus a temperature

difference of 3600 deg., this would give a cooling constant of $b = <10.9 \times 10^4$. This would give a residual concentration of $a = 5.1$ per cent, out of $a_0 = 7.95$ per cent, corresponding to 4000 deg. abs., or 64 per cent.

Thus, the highest concentration which would be expected from a 1-cm. arc by molecular diffusion would be less than 5.1 per cent, and this only if the gas pressure is so low that the free path of the molecules is of the magnitude of 1 cm.

Assuming then an arc terminates in the throat of an expansion nozzle, and the gases are sucked through the arc into the nozzle, expanding therein to lower pressures and thus lower temperatures.

Let p_0 = initial pressure of the gas, and T_0 = arc temperature at this pressure.

Expanding to lower pressure p , and corresponding temperature T , the expansion velocity is, by (86):

$$s = \sqrt{\frac{2gR}{a-1}} (T_0 - T) \quad (86)$$

The section of the gas stream at velocities s is:

$$S = \frac{v}{s}$$

where v is the volume per unit time, as by (83):

$$\frac{v}{v_0} = \left(\frac{T_0}{T}\right)^{\frac{1}{a-1}}$$

It is:

$$S = \frac{v_0 T_0^{\frac{1}{a-1}}}{s T^{\frac{1}{a-1}}}$$

and by (86)

$$S = \frac{v_0 T_0^{\frac{1}{a-1}}}{\sqrt{\frac{2gR}{a-1}}} T^{-\frac{1}{a-1}} (T_0 - T)^{-0.5}$$

and this section is a minimum for:

$$\frac{dS}{dT} = 0, \text{ or: } \frac{d}{dT} \left[T^{\frac{2}{a-1}} (T_0 - T)^{\frac{1}{a-1}} \right] = 0$$

this gives:

$$\frac{T_1}{T_0} = \frac{2}{a+1}$$

$$= \frac{5}{6} \text{ for air} \quad (97)$$

This gives the temperature at the nozzle throat, and by (83):

$$\frac{p_1}{p_0} = \left(\frac{T_1}{T_0}\right)^{\frac{a}{a-1}} = \left(\frac{5}{6}\right)^{3.5} = 0.528 \quad (98)$$

That is, the pressure at the nozzle throat is 0.529 p_0 . The velocity at the nozzle throat is, by (101) or (86):

$$s_1 = 37.7 \sqrt{\frac{T_0 - T_1}{a-1}}$$

$$= \frac{37.7 \sqrt{T_0}}{\sqrt{6}} = 15.4 \sqrt{T_0} \quad (99)$$

Thus, at arc temperature $T_0 = 3600$ deg. abs.,
 $s_1 = 924$ m.sec.

If now the arc terminates at the nozzle throat, and the arc gases further expand to the pressure p and temperature T , Table XIII gives values of $\frac{T}{T_0}$ for various values of $\frac{p}{p_0}$ by equation (83).

Assuming now that the divergence of the nozzle is such that the temperature along the nozzle drops by expansion at the rate of $\dot{\tau} = 1000$ deg. per cm. The

TABLE XIII. ELECTRO-THERMAL EQUILIBRIUM

		I									
		Cooling rate: $b = 10^5$ deg. per sec.									
		$T_1 = \frac{\log_{10} (33-a) + 12.971}{5.731} \times 10^3$									
Residual concentration, per cent:	$a =$	0	4	8	12	16	20	24	28	30	32
Arc temperature, deg. abs.:	$T_1 =$	2535	2525	2515	2500	2480	2460	2430	2380	2350	2270
										32.5	32.9
										2215	2090

cooling constant along the path of the expanding gas then would be

$$b = 100\delta s = s \times 10^5 \quad (100)$$

Where the factor 100 reduces from meters to centimeters.

Assuming as an instance an expansion ratio: $\frac{p}{p_0} = 0.2$.

This would give a temperature ratio: $\frac{T}{T_0} = \left(\frac{p}{p_0}\right)^{\frac{1}{3.5}} = 0.631$.

Hence, at $T_0 = 3600$, an expansion temperature: $T = 2270$ deg. abs., and at this temperature the reaction velocity has already dropped so that by rapid further cooling, little loss may be expected.

This gives a velocity, by (86): $s = 37.7\sqrt{T_0 - T} = 1375$ m.sec.

This gives a cooling rate: $b = 1.375 \times 10^5$.

Hence a residual concentration: $a = 4.5$ per cent. While the throat velocity: $s_1 = 924$, would give a cooling rate $b_1 = 0.924 \times 10^5$.

Hence a residual concentration: $a_1 = 4.4$ per cent.

Thus an average NO concentration of about 4.45 per cent might be expected, while the initial concentration, at 3600 deg. abs., is 6.15 per cent.

It is interesting to note that the rapid expansion by terminating the arc in the throat of an expansion nozzle would give very high concentrations, that is, save most of the NO produced by the arc, without diluting the gases with masses of cold air, and thereby lowering the concentration and thus requiring the enormous absorption plant: a concentration of 4.45 per cent would reduce the size of the absorption plant—which is the largest part of the cost of installation—to about one-quarter of the present size.

Thus this method requires further experimental investigation regarding its feasibility.

Water-cooled nozzles of a high ferrotungsten would probably stand the temperature for a considerable time, especially if the throat is made replaceable. A turbine wheel in front of the nozzle would further cool the gases and abstract their velocity, without any temperature rise due to the destruction of their kinetic energy. A steel wheel would probably stand the temperature of the gases indefinitely, as it is exposed to it only intermittently for a very short time.

When expanding from atmospheric pressure p_0 to $p = \frac{1}{5}$ to $\frac{1}{10}$ of an atmosphere, it would need recompressing the gases before they can be sent into the absorption system and then returned into the air. It thus would be preferable to initially compress the air to a pressure of $p_0 = 5$ to 10 atmospheres, and then expand to atmospheric pressure. The turbine wheel abstracting the kinetic energy of the gas jet would then, if of

reasonable efficiency, give ample power for the initial compression.

However, in this case the serious question arises whether an arc at 5 to 10 atmospheres pressure is not materially hotter than one at atmospheric pressure, and as the result thereof the temperature drop during the adiabatic expansion would not be sufficient to carry down to safe temperatures.

An investigation of the temperature of air arcs at various pressures would therefore be of primary importance.

(Part IV, the last of the series on theoretical study of nitrogen fixation by the electric arc, will be published in our next issue.)

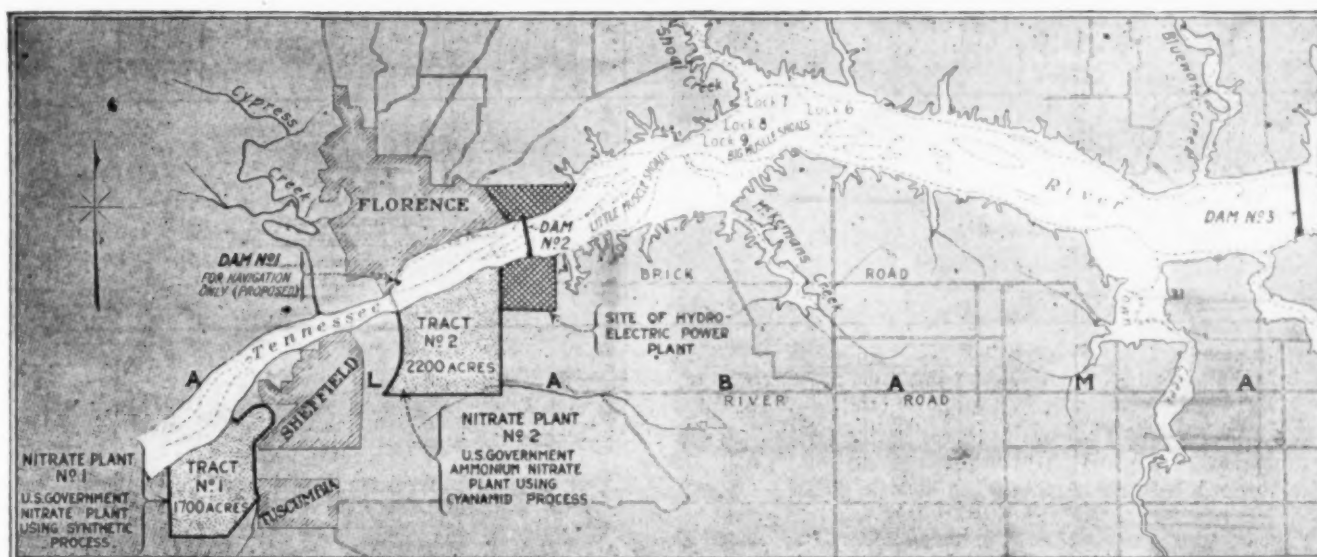
Phosphate Reserves of Pacific Islands

According to a memorandum laid on the table of the New Zealand House of Representatives by the President of the Board of Agriculture, the reserves of phosphate of the Island of Nauru, in the Pacific, are sufficient to meet the demands of the world for two hundred years. Information obtained from a reliable source, says the *Board of Trade Journal*, indicates that anything from 80,000,000 to 100,000,000 tons are available, and possibly more. The quality of the phosphate is said to be of the highest grade (85 to 86 per cent), and it is claimed that this island contains the largest known quantities of high-grade phosphate in the world. The present output of the island has been somewhat interfered with by the war, but the average yearly production is in the neighborhood of 150,000 tons.

There are several phosphate islands in the Pacific, these including Ocean Island, where the Pacific Phosphate Co. has the mining rights, this company also holding an interest in a French company which works the Makatea Island deposits; Christmas Island; Angaur Island, which, according to a German authority, contains 2,500,000 tons ranging from 81 to 83.6 per cent, though another authority places the available phosphate between 300,000 and 600,000 tons; Surprise Island; Clipperton Island; Walpole Island, and Malden Island. Christmas Island, referred to above, must not be confounded with an island of the same name near Java.

Phosphate Deposits in the Netherlands

Phosphate deposits have been discovered in the eastern part of Holland, at a place called Ootmarsum, in the Twente District. About thirty tons of 15 to 20 per cent phosphate are being produced each day, and are being sold locally at prices corresponding to the prices of imported phosphate. The stratum varies from 7 in. to 3 ft. in thickness, but on account of the fact that it is not continuous the work of extracting the rock is very expensive. In some places the stratum is on the surface, in others it is as much as 25 ft. beneath the surface.



DAM SITES AND FIXED NITROGEN PLANTS

Muscle Shoals Hydro-Electric Development

Wilson Dam on the Tennessee River in Alabama—Corps of Engineers, U. S. Army, Making Rapid Progress Toward Completion in 1922—Power Generated Will Reduce Operation Costs at Nitrate Plant No. 2

BY CHESTER H. JONES

MANY persons interested in the discussions at Washington over the fixed nitrogen situation are not fully informed as to the location of the Government nitrate plants and water-power development and the relation between them. The name Muscle Shoals has been used in referring to both water-power and chemical plants, causing much confusion. The map shown herewith will clarify this misunderstanding.

Muscle Shoals originally designated the stretch of river up stream from the city of Florence and was later also applied to the permanent village erected by the Government on the 2,200-acre tract in connection with Nitrate Plant No. 2. It is here the \$70,000,000 cyanamide plant now stands idle. The rated capacity is 110,000 tons of ammonium nitrate (38,500 tons fixed nitrogen) per annum. The process has proved successful and the plant is practically completed.

Tract No. 1 (1,700 acres), southwest of Sheffield, is the site of Nitrate Plant No. 1, where the modified Haber process plant was installed by the Ordnance Department, U. S. Army, under the advisement of the General Chemical Co., and a permanent village was built. This plant, also standing idle, has a capacity of about 18,350 tons of ammonium nitrate (6,425 tons fixed nitrogen) annual production and the construction is completed, with a total cost of property, including village, of about \$14,000,000. The process did not operate successfully, but may be developed to do so through research.

Nitrate Plants Nos. 3 and 4, located at Toledo and Cincinnati respectively, were partially completed in the erection of factory buildings. These are being used as storehouses for ordnance material. The bills now before

Congress refer only to the industrial properties in Alabama and research laboratories elsewhere.

On June 3, 1916, Section 124, H. R. 12,766, carrying an appropriation of \$20,000,000, became a law (Public Document 85) and was directed chiefly toward the erection of the dams, although about \$6,000,000 was expended in building Plant No. 1. The money for Plant No. 2 was taken from another general war fund of over \$300,000,000 subsequently appropriated by Congress.

The nitrate plants have always been under the direction of the Nitrate Division, Ordnance Department,



SOUTH ABUTMENT—EFFECTS OF BLASTS IN DRILL WELL HOLES



LOOKING NORTH TOWARD JACKSON ISLAND—MAIN CAMP ON NORTH BANK

while the dams were handled, separately and apart, by the Corps of Engineers, U. S. Army.

Practically nothing was accomplished toward construction of the dams during the war, because it was known that water power could not be secured in time to meet the emergency. The work was therefore delayed until such time as labor conditions became more favorable.

The operations at the Wilson Dam (Dam No. 2) are now proceeding under the immediate direction of Colonel Lytell Brown at Muscle Shoals, who reports to the Chief of the Corps of Engineers in Washington. About 5,000 workmen are engaged. Prior to Jan. 1, 1920, \$3,679,000 was expended, leaving about \$14,000,000 on hand. It is roughly estimated that the total cost of this dam will



LOOKING SOUTH, COFFER DAM NO. 1 AND JACKSON ISLAND

be somewhat in excess of \$20,000,000 under existing conditions and the work completed in 1922. No immediate construction will be carried out on Dams No. 1 and No. 3 and the navigation features.

WILSON DAM DETAILS

The development is run-of-river, there being no storage capacity for reserve water. The plans of construction closely follow those outlined in the report prepared by Major H. Burgess, Corps of Engineers, and submitted to Congress through military channels during June, 1916, House Document 1,262, Sixty-Fourth Congress, First Session, Serial 25; 6,979.

This report embraces the whole project of three dams and canal through the river shoals. The old canal is inoperative for about six months each year and is limited to the passage of smallest river boats. The



CONCRETE FORMS FOR HIGH LEVEL CONSTRUCTION BRIDGE ON JACKSON ISLAND

navigation improvement will require the eventual erection of Dam No. 3.

The Wilson Dam (No. 2), crossing Jackson Island (the latter shown in dotted outline on the map), has a spillway crest of 3,080 ft., a height of 94 ft. and a total base of 177 ft. Of this base dimension 57 ft. is



DOWNSTREAM HALF OF COFFER DAM NO. 1, PUMPED OUT, AND HIGH LEVEL CONSTRUCTION BRIDGE

taken up by a spillway apron, anchored to the river bed and provided with necessary weepholes. While the river bed is composed of country rock, harder than concrete, it is liable to become dislodged in large blocks. Hence the wide apron is necessary.



NORTH SHORE MIXING PLANT, SHOPS AND WAREHOUSE

Legal Notes

BY WELLINGTON GUSTIN

A Lesson on Aluminum and Sales Contracts

The Supreme Court of Errors of Connecticut has handed down its decision in the suit brought by the Brown Bag Filling Machine Co. against the United Smelting & Aluminum Co. for breach of contract to buy "rod aluminum." (107 Atl., 619.)

The facts out of which this action arose, as stated by the court, appear to be that in February, 1916, the plaintiff had on hand about 34,000 lb. of aluminum rods of various sizes, and the right by contract to about 4,400 lb. of aluminum not drawn and to be specified. Plaintiff was not a dealer in the metal, but had this quantity on hand as a result of his failure to place a certain contract requiring the use of aluminum.

ACCEPTANCE OF PART OF ORDER

It was admitted that about Feb. 18, 1916, the parties entered into a written contract by which the defendant agreed to buy of the plaintiff 34,078 lb. of aluminum rods at 80c. per lb., to be drawn in sizes to be specified by the purchaser. Now, 1,490 lb. of this aluminum was delivered to and received by the defendant, not needing to be changed in size.

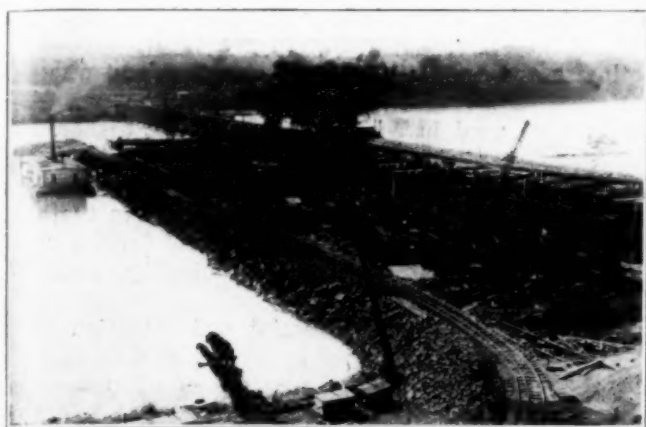
This action was brought to recover damages by the refusal of the defendant to take and pay for the balance of the aluminum rod described in the contract. The defendant smelting company in defense contended that the aluminum rod of plaintiff was not pure aluminum, and set up a counter-claim for damages from plaintiff's failure to deliver pure aluminum. Now, the substantial controversy was whether the contract called for pure aluminum or the aluminum rods of commerce as understood in the aluminum trade, and whether, by acceptance of a part of the rods, the defendants in law accepted the whole.

In the second count of his complaint the plaintiff sought to recover the price of the rods and coils of aluminum wire which were delivered. The item 4,400 lb. became the subject of a separate contract as to which no question arises in this case.

DOES ROD ALUMINUM MEAN PURE ALUMINUM?

The order given by defendant described the material as "rod aluminum," to be "drawn to specifications." By the direction of the defendant the plaintiff sent the rod to the mill to be redrawn according to specifications furnished by the defendant. The defendant then requested that two sample coils of $\frac{3}{8}$ -in. wire be drawn and sent to it for examination. The plaintiff advised defendant that the manufacturer was of the opinion that the rods were too hard to furnish a satisfactory wire of that size. However, two coils of wire were drawn and sent to the defendant, who refused to give further specifications or to accept the wire at the mill on the ground that the rod aluminum offered by the plaintiff was not of the quality purchased.

The Supreme Court said the case turns upon the meaning of the terms of the written contract, it having appeared that the trade designation of the rods of plaintiff was 15S or 15SH. Now, 15S is a grade of alloyed aluminum containing about 86½ per cent pure aluminum. H is the symbol for annealed hard. O is a symbol for annealed soft, while 2S is the symbol for commercially pure aluminum, that being 98 to 99



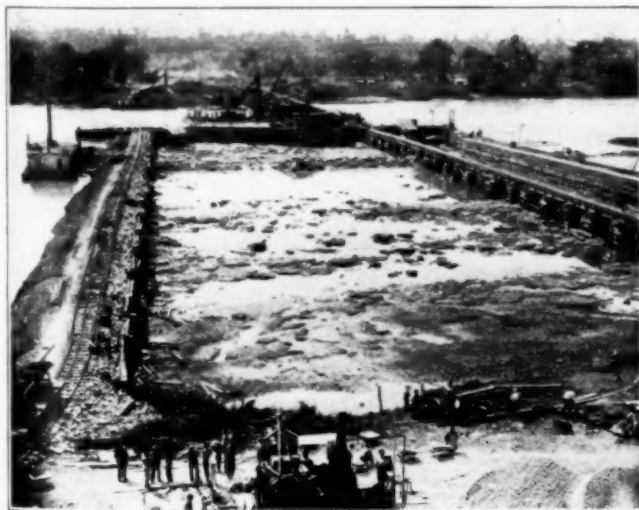
UPSTREAM HALF OF COFFER DAM NO. 1, PUMPED OUT

The design provides for a maximum depth of water on the crest of 13 ft. at a river discharge of 500,000 cu.ft. per sec. The wasteway section will carry 10,000 cu.ft. per sec. The working head is between 95 and 92 ft.

POWER ARRANGEMENTS

The power house will contain foundations for twelve 40,000-hp. water turbines, single runner type. The estimated primary power is 100,000 kw., with a total primary and secondary power of 300,000 kw.

The 60,000-kw. steam plant on the site of Nitrate Plant No. 2, connected by an 80-mile transmission line with the 30,000-kw. steam plant on the Black Warrior River, may be operated in conjunction with the hydro-electric units. Both steam plants, together with the transmission line, are Government properties and have been tested and run in connection with the chemical process operation.



COFFER DAM NO. 1, PUMPED OUT, SHOWING CHARACTER OF ROCK BOTTOM

The accompanying illustrations give an idea of the progress made on the Wilson Dam at the beginning of 1920. A large number of the workmen occupy living quarters in the village at Nitrate Plant No. 2. Several hundred thousand dollars' worth of materials left over from the construction work at the chemical plant is being turned to good use in the work at the dam.

The writer is indebted to Colonel Pillsbury for information which he supplied during the preparation of this article.

per cent aluminum. In its narrow sense the question was whether rod of the 15S quality, or alloy, in the trade answered to the description and filled the order for "rod aluminum." The jury in the trial court found that it did, or found an acceptance of the rod by the defendant, and rendered a verdict for the plaintiff on both counts of the complaint. From this verdict the defendant appealed.

On the appeal the Supreme Court found that the negotiations were entirely in writing, including letters and telegrams, and shown in the evidence. They conclude with the direction by the defendant to ship the rod to the mill for redrawing and without exception referred to the material as "rod aluminum." If, in accordance with the meaning of the term in the trade, the aluminum in question was rod aluminum, the contract was met by the plaintiff, said the court. Much testimony by witnesses skilled in the business was given at the trial as to whether "rod aluminum," either standing alone in the purchase order or with the additional words "to be drawn to our specifications," without further description, had a definite established meaning in the trade, and if so whether the meaning was pure aluminum or a standard alloy, or, the court said, to put it more definitely, whether the alloy 15S, containing 86½ per cent of aluminum, furnished or offered by the plaintiff, in the trade filled a contract for rod aluminum.

POINTS TO BE CONSIDERED BY THE JURY

Further, the court said the 1,490 lb. was shipped to defendant, as needing no redrawing, and upon its order, and resold by defendant in the original package. Now, the defendant claimed that this was sold under the belief that it was pure aluminum, and that two months later its purchaser made a claim based upon the fact that these rods were not pure, but were only 93 per cent aluminum. However, there was evidence, the court said, from which the jury might have found that no complaint was ever made about this rod by defendant and that it was accepted as part of the entire purchase. Further, the court held, the jury was entitled to consider from the negotiations whether the order was not for the specific goods that plaintiff had, and that if the rods delivered or offered were those and only those the plaintiff had on hand when plaintiff made its first inquiry, and were in fact rod aluminum as understood in the trade, then the plaintiff filled its contract, whatever the specific alloy might be. Upon the charge as given by the trial court the jury was fully warranted in rendering a verdict for the plaintiff, said the Supreme Court.

But the defendant contended that the trial court erred in instructing the jury that it might take into account the experience, or lack of experience, of the parties in the aluminum trade in determining the meaning of the term "rod aluminum" in the contract. It claimed that this language would mislead the jury to the injury of the defendant, as tending to excuse the plaintiff for its lack of knowledge if otherwise the facts should turn out to be to his disadvantage. And so the court held. It said that upon the facts generally no special meaning was presumed to be attached to the term other than the ordinary meaning as used in the trade, to which both parties were bound, whether ignorant or skilled.

Since the sole question was whether "rod aluminum" means pure aluminum the lower court was held to have erred in instructing the jury to determine whether the

words "to be drawn to our specifications" had any distinct well-known meaning in the trade, applied to both size and composition, or to size only, and whether the plaintiff knew or ought to have known that the words were used in such special sense. Further, the Supreme Court held that the sale being of specific goods designated as "rod aluminum" in the written contract and in the written negotiations leading up to the contract, it was the duty of the seller to furnish "rod aluminum" as that term was ordinarily used in the trade.

On the point as to the receipt and retention of a portion of the goods shipped by the plaintiff to defendant the court held that the retention of possession without any claim indicating that the buyer had any fault to find with the goods was sufficient to justify instructing the jury that under the circumstances such retention amounted to an acceptance.

Again, the lower court directed the jury's attention to letters bearing on the construction the parties took of the contract. These appeared to be self-serving letters, said the court, and not a practical construction of the contract agreed upon by the parties. They greatly favored the plaintiff, and since there was no ambiguity in the contract other than in the meaning of a technical trade term, the Supreme Court held this erroneous.

On the proposition that defendant's acceptance of a part of the goods under the order was an acceptance of the whole, the court held that the acceptance of a single lot of "rod aluminum" did not preclude the buyer from refusing to accept subsequent deliveries which in fact did not conform to the contract.

CONTROVERSY AS TO DAMAGES

Some controversy arose over the court's instruction as to damages, which said: "Such damage would include whatever loss the plaintiff has sustained by reason of the loss of his bargain." But this was followed by more: "Damage for breach of a contract to buy goods ordinarily consists of the difference between the contract price and the market value of the goods at the time the buyer ought to have taken them."

The court held this not to be error and as following the sales act. However, it had been agreed between the parties that the plaintiff would claim damages on a market value of 50c. a lb. for the rods the defendant refused to take, and that the defendant on its counter claim would base its claim at \$1.12½ per lb. for pure aluminum which it claimed to have bought; the contract price being 80c. per lb.

However, because of the error pointed out by the Supreme Court, the judgment was set aside and the case remanded.

New Source of Food Supply

Prof. P. W. Claassen of Cornell University published an article in a late number of the *Scientific Monthly* on "A Possible New Source of Food Supply," in which he called attention to an excellent, palatable flour from the roots of the common cat-tail (*Typha*) that grows abundantly in swamps. There are in the United States exclusive of Alaska, about 139,855 square miles of swamp land, and thousands of acres of this land are cat-tail marshes. An ordinary cat-tail swamp would yield 5,500 lb. an acre of edible flour which has substantially the same food value as corn or rice flour. The flour is said to be pleasing and palatable. The Indians used it freely.

Preventing Accidents in Gas Plants*

BY J. F. CONNER

THE title may lead persons unacquainted with the operation of gas plants to assume that employment in such plants is an extra-hazardous occupation, fraught with unusual danger. With few exceptions, the accident hazards met in gas plants do not materially differ from those found in other industries where mechanical and construction operations are the rule.

My conclusion in this respect is based on experience gained from a close acquaintance with such operations, receiving reports of accidents and investigating their causes, and from making accident hazard inspections of many gas plants.

INHERENT HAZARDS OF THE INDUSTRY

The industry has, of course, inherent hazards. There are certain zones in gas works where in the course of operation pockets of gas may accumulate and, with the admixture of air, serious explosive hazards may form. Precautions should be taken against such conditions arising. The ventilation, lighting and the lighting system of such zones are questions for consideration. Such places should be as well ventilated as conditions will permit. In the lighting system, approved types of keyless socket, vapor-proof globe electric lamps with remote switch controls should be used, to guard against the possibility of the gaseous atmosphere being fired by an electric arc. Warning signs of size sufficient to attract attention, cautioning against smoking and the carrying of naked flames in such zones, should be posted in conspicuous places.

PRECAUTIONS AGAINST DUST EXPLOSIONS

Like precautions should also be taken to guard against dust explosions in coal crusher rooms and pits where the air may be heavily charged, especially while the crushers are in operation, with minute particles of carbon which may be ignited and exploded by contact with an exposed flame. Dust explosions, while infrequent in gas plants, have been known to occur frequently in other industries with disastrous results.

It may be unnecessary to state that all warning signs should be kept in clear, legible condition if any benefit is to be derived from their posting. The writer has found, in the course of inspections, instances of lettering on painted wooden signs having become illegible from exposure to weather, and enamelled metal signs covered by accretions of smut and dust.

RESPIRATORS FOR EMERGENCY WORK

Emergency conditions may arise which will require working against live gas. In such instances, the workman should be protected by a suitable type of respirator. The same precaution should be taken when a workman is required to enter any gas-charged atmosphere and in every instance he should be under the clear observation of a person outside the danger zone, who should be prepared to render immediate assistance. Oil and other tanks in which gases are present should, where conditions will permit, be first purged by steam and well ventilated before entrance is made to such enclosure. Life lines can in such work be used to advantage.

Generally speaking, gas plants are usually well

guarded mechanically. Occasionally, however, accidents occur on machinery due to guards being temporarily removed during repairs and failure to replace guards before putting the machines in operation again, or possibly to an exposure being considered too remote to warrant guarding.

SIMPLE HAZARDS CAUSE MOST ACCIDENTS

A review of cases reported shows that the causes responsible for the greater number of accidents are due to the simple hazards found in all industrial establishments such as tripping, falling, slipping, and lifting, protruding nails, to the use of defective hand tools, ladders, scaffolds and makeshift supports that give insecure footing, and other like minor hazards, and to disregard of instructions to wear goggles when engaged in work in which the eyes are exposed to flying particles or splashing liquors.

EDUCATION THE GREATEST SAFEGUARD

The safeguarding of machinery and the installation of other mechanical devices for the prevention of accidents is unquestionably a necessary measure in any well-ordered plant, but in many cases the guards cannot be made absolutely fool-proof, so that in the final analysis, the greater reliance for preventing accidents must be placed on the human agency. If we are to continue to look forward to a reduction in the accident frequency, greater efforts must be made to educate the workman to know the dangers that beset him and others, from carelessness, thoughtlessness, and inattention on his part, and to arouse and maintain the accident prevention spirit in him.

METHODS OF REACHING THE WORKMEN

How we shall best reach the workmen by educational propaganda is a question of personal opinion. Reasoning with the men collectively is usually attended by good results. In obdurate cases, however, resort to individual approach brings the best results. We should not, however, be too hasty in censure of the workman for apparent indifference to safety. He possibly may be influenced by environment and be reflecting the attitude of his superiors to this important question. The problem, to my reasoning, should first be brought convincingly to the attention of the man higher up, the man directly in charge of the operation. If he meets it, as he should, in a spirit of serious interest and by precept and example sets the standard for his subordinates, let it be known that he is keenly alive to any failure or disinterestedness on their part to shoulder their duty, the indifference, if any, of the foremen and sub-foremen will quickly vanish and those in positions of responsibility will, figuratively speaking, be standing on their toes and showing greater activity toward preventing accidents. The interest they show is bound to be reflected in the workmen and with the environment of good house-keeping, a place for everything and everything in its place, which must of necessity be part of the program, there will come a subconscious awakening of the prevention spirit in the workmen and that is the dominating factor in preventing accidents.

Team work as outlined means co-operation. When the force of co-operation is behind the punch for safety, the fight for accident prevention is soon won.

Safety Supervisor,
United Gas Imp. Co.,
Philadelphia, Pa.

*Paper read before the Eighth Annual Safety Congress of the National Safety Council, Cleveland, Ohio, Oct. 3, 1919 (slightly abridged).

Explosion Hazard in Steel Mills From Partly Consumed Coal Dust

FOR many years natural gas has been the principal fuel used in the heating furnaces in those mills located in the Pittsburgh district which manufacture bolts, nuts, rivets, picks, mattocks and small forgings. For a number of years the steady supply of this fuel has been more or less interrupted owing to the increased demand for domestic use and to the increasing difficulty in securing an adequate amount of natural gas.

This condition has led a number of the steel companies to substitute pulverized coal as a fuel for the furnaces. Elaborate installations have been made for pulverizing the coal and conveying it to the furnaces. Soon after the furnaces commenced to operate with pulverized coal, large quantities of fine dust began to accumulate on the platforms over the furnaces, the roof trusses, on the outside of the various pipe lines, electric cables and even on the roofs of the buildings.

Some of the companies, becoming alarmed, requested the Bureau of Mines to make an investigation to ascertain the liability of this dust to cause an explosion. While conducting this investigation, an explosion occurred in another mill which caused the death of one man and severely burned two others.

A report of this investigation by L. D. Tracy is included in the *Monthly Reports of Investigations* for December, 1919.

Eleven samples of the dust (which for convenience has been termed "mill dust") from various locations in the different mill buildings were taken and submitted to chemical analysis, microscopic examination and also to flame and explosion tests. Table I shows the range of the proximate analyses of these samples of mill dust, compared with analyses made upon five samples of the pure coal dust, before passing into the furnaces. The inference drawn from a study of these figures, namely,

TABLE I. PROXIMATE ANALYSES OF COAL DUST

	Mill Dust, per Cent	Pure Coal Dust, per Cent
Volatile matter.....	6.3 to 23.54	30.50 to 36.81
Fixed carbon.....	50.88 to 67.08	46.86 to 52.48
Ash.....	22.29 to 32.16	9.26 to 21.84

that for some reason the pulverized coal was being blown out of the combustion chambers of the furnaces before it had been thoroughly consumed, was further substantiated by microscopic examination.

DETERMINATION OF EXPLOSION PRESSURES

The several samples of dust were also subjected to tests to determine the pressure which might be exerted by the dust in a possible explosion, as compared with

TABLE II. EXPLOSION PRESSURES DEVELOPED BY COAL DUST IN CLEMENT-FRASER APPARATUS

Sample	Volatile Matter, per Cent	Explosion Pressure, lb. per Sq. In.
Pure coal dust.....		14.5
Mill dust.....	23.54	10.21
Mill dust.....	20.6	8.7
Mill dust.....	15.91	4.6

pure pulverized coal; this test was conducted in the Clement-Fraser apparatus (described in Technical Paper 141 of the Bureau of Mines). Briefly, this apparatus consists of a glass globe, possibly 6 in. in diameter, containing a small platinum coil which is electrically heated. A sample of dust is blown against the heated coil and

the pressure of the resulting explosion is recorded by a pressure indicator. In these tests about 0.003 oz. of pure pulverized coal was blown by about 8 cu.in. of oxygen under a pressure of 5½ in. of mercury against the platinum coil, which had been heated to a temperature of 2,200 deg. F. The average pressure obtained was 14.5 lb. per sq.in. The results of several tests on mill dust are given in Table II.

Further experiments to determine the explosibility of the mill dust were carried on in the dust explosion gallery of the Bureau. Tests were also made to determine the inflammability of the dust, one of these being the heating of a clay roasting dish 6 in. in diameter, in a furnace to a temperature of 2,000 deg. F. When the dish had reached this temperature, about one-sixth of an ounce of "mill dust" was quickly dropped in a cloud upon it. Another test was made by blowing a small amount of the dust in a cloud across the flame of a Meker burner.

These methods of testing were valuable, as they were almost identical with the conditions in and around a steel mill where the red hot iron and steel are often in close proximity to clouds of dust. The results obtained are summarized in Table III.

TABLE III. INFLAMMABILITY TESTS ON MILL DUST

Per Cent Volatile Matter in Sample	Observations
23.54 } 20.60 }	Burned readily with more or less explosive violence.
15.91 } 13.45 } 11.5 }	Burned readily but without violence.
11.25 } 10.99 }	Slightly inflammable.
7.17	Would not burn at all.

From the above-described tests and from similar tests with dust from the steel mills of other companies, it has been fairly well demonstrated that the division point between mill dust which will explode and that which will not explode is reached when the dust contains about 11 per cent of volatile matter.

EXAMPLE OF FIRE HAZARD

A good example of the great danger from mill dust, caused by the use of pulverized coal, is the fire which occurred a few years ago in a plant in which there were a number of puddling furnaces, some of which used pulverized coal as a fuel. A draft of air blew some of the coal dust over some red hot iron or slag. The dust immediately ignited and communicated the flames to the roof trusses. These were covered with fine dust which caused the roof to burn so quickly that the men barely escaped in safety from the building.

STOPPING FANS TOO SOON A DANGEROUS PRACTICE

Many of the systems distributing coal dust to the furnaces consist fundamentally of fans which drive the dust from the storage bins through large pipes, from which small feed lines lead to the burners. It is the practice in some mills, when the furnaces are shut down, to stop the fan before all the pulverized coal in the pipe line has been thoroughly blown out. This is a rather dangerous practice, for the reason that, when the pressure from the fan is stopped, there is liable to be a back draft from the furnace which may take live sparks into the feed line. These sparks will smoulder until the fan is started again and then will be fanned into a

flame, igniting the dust in the feed line with a consequent explosion. The fatal explosion mentioned in the first part of this article was evidently caused thus.

OTHER PRECAUTIONS TO BE TAKEN

The roof trusses, pipes, platforms and all other places upon which any considerable amount of dust might accumulate should be kept thoroughly cleaned. In cleaning these trusses, platforms, and so on, no flame torches or open lights should be used, because of the danger of igniting any dust cloud which might be raised.

In some of the furnaces in which natural gas has been used, it is customary to keep both the gas and pulverized coal connections ready for service. If coal is being used, the gas connection should be cut out, as there is a chance that a leaky valve may allow gas to accumulate in the main coal feed and become ignited by a back fire from the furnace.

All electric switches and motors should be kept from dust and all electric wiring should be kept away from any place where dust in large quantities is liable to accumulate. As far as possible the wiring should be carried in conduits.

PROTECTION AGAINST STATIC DISCHARGES

Provision should be made to protect properly all pulverizing machinery from damage which might be caused by an explosion due to the ignition of coal dust from static electricity in the machinery. All conduits, grinders and other parts in which an electric spark is liable to be produced should be grounded. Care should be taken that there is no way in which the coal dust can come in contact with hot metal, especially where pulverized coal storage bins are close to hot metal or hot slag.

CONCLUSION

The substitution of powdered coal for natural gas in the heating furnaces of the steel mills is of comparatively recent date, and there is hardly any doubt that the practice will become more general in its application as an adequate supply of natural gas becomes more difficult to obtain. As the problem of mill dust and the consequent danger therefrom seems to be prevalent in some plants using pulverized coal, it would seem imperative that every mill official should take precautions to prevent loss of life and property by an explosion or fire from this dust.

American Glass in Canada

Prior to the World War Canada's principal source of supply for plate glass was Great Britain, with Belgium second, the imports from the two countries in 1914 being 2,307,670 and 1,976,563 sq.ft. respectively, whereas during the fiscal year 1919 Canada obtained but 152,558 sq.ft. from Great Britain and none from Belgium. At present over 99 per cent of the glass imported into Canada comes from the United States, the quantity in 1919 being 1,736,895 sq.ft., whereas in 1914 only 299,042 sq.ft. came from that source.

Canada has been unable to secure its pre-war supply of plate glass, its total imports last year being but 1,889,451 sq.ft., against 4,672,534 in 1914, the reason being that the United States has become the world's chief source of supply, and was not in a position to meet the demand which was so suddenly made upon its manufacturers.

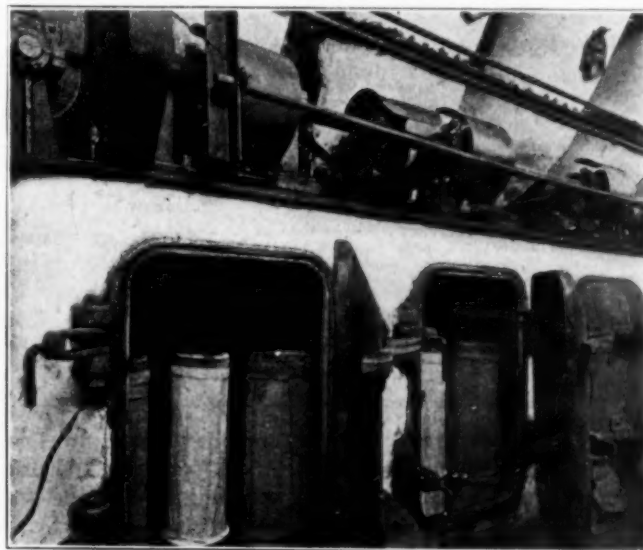
Canada has made some progress in the manufacture of plain window glass since the outbreak of the war.

Synopsis of Recent Chemical and Metallurgical Literature

Cleaning Blast-Furnace Gas.—A description of a dry method of cleaning iron blast-furnace gas previous to use in engines, stoves or boilers is given in *Iron and Coal Trades Review*, Dec. 19, 1919. Fifty-nine installations of this Halberg-Beth process are either in operation or under construction in Europe, with a total capacity of 174,000,000 cu.ft. per hr. (4,900,000 cu.m.), and it is claimed that the system overcomes the many difficulties in wet cleaning associated with providing and handling the very large amounts of water and power necessary.

Blast-furnace gas, after passing through an ordinary cyclone catcher for coarse dust, goes into a series of cooling towers, working like a surface condenser, and reducing its temperature to about 55 deg. C. From this it is taken to the filter bags by way of a preheater, where waste steam or gas superheats it about 10 deg. to prevent any moisture condensing during the next step.

The bag house is unique. One unit is divided into twelve sections, each containing twelve bags, fastened to a thimble floor as usual; and with closed tops suspended from a shaker frame. In operation, a suction fan draws clean gas through the fabric for about 7



TOP FLOOR OF FILTER HOUSE SHOWING SHAKING MECHANISM AND INSPECTION DOORS (OPEN) WITH FILTER BAGS IN POSITION

min., when the inlet and outlet valves for that section are reversed, placing pressure on the clean gas outside the bags. Hoops shown in the accompanying illustration prevent the bags from collapsing, the counter-current of gas loosens dust in the fabric, and at the same time the upper suspension is vibrated up and down. In about 15 sec. the valves are reversed and a new cycle starts.

Gas at about 50 deg. C. is sent to burners or to gas engines. In the latter case it is cooled by sprays and then passes through a water separator. A content of 0.01 g. per cu.m. solid is easily attained in everyday working from dirty gas carrying 6 g., while 0.001 g. per cu.m. is often continuously attained. Filter bags last

at least six months, one year being a good average. One horse-power per 10,000 cu.ft. (280 cu.m.) gas per hr. is required to operate the fans, valves and shaking mechanism.

The Problem of Nitrogen.—The November-December issue of *Giornale di chimica Industriale* contains an important article by CARLO TONIOLO on the problem of nitrogen and its world and national importance. After describing the vital needs of nitrogen for the progress of civilized humanity, Mr. Toniolo dwells on the special need of Italy and gives comparative tables on capital required to produce nitrogen by the arc, cyanamide and synthesis of ammonia processes. These data, although specific to Italy, are of sufficient importance to be summarized in the accompanying Table IV.

Tables I and II show respectively the consumption of energy and of carbon in the nitrogen industries, and Table III shows the present status in Europe and North America of the potential and developed hydro-electric power.

TABLE I. CONSUMPTION OF ENERGY

Process	Kw.-Hr. per Kg. N	Kw.-Yr. per Ton N
Arc.....	70-75	8.4
Cyanamide.....	17-20	1.7-2.3
Synthesis of ammonia.....	1.5	0.17

TABLE II. CONSUMPTION OF CARBON

Process	Kg. per Kg. of N	Tons per Ton of N
Arc.....	51	51
Cyanamide.....	For energy.....	3
	For reaction.....	20
Total.....	23	23
Synthesis of ammonia.....	For reaction.....	3.6-3.8
	For energy.....	1.5
Total.....	5.2	5.2

TABLE III. POTENTIAL AND DEVELOPED HYDRO-ELECTRIC POWER

Country	Potential	Developed
United States.....	20,000,000	5,000,000
Canada.....	6,000,000	1,250,000
France.....	6,000,000	500,000
Norway.....	5,500,000	850,000
Spain.....	5,000,000	300,000
Italy.....	5,000,000	750,000
Sweden.....	5,000,000	600,000
Switzerland.....	1,500,000	400,000
Germany.....	1,000,000	500,000
Great Britain.....	700,000	60,000

He also describes the method developed by the Badische Anilin und Soda Fabrik at Oppau for the production of ammonium sulphate, ammonium chloride and urea based on the reactions:

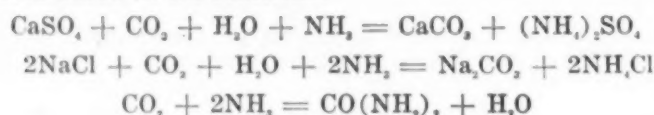


TABLE IV. CAPITAL INVESTMENT IN NITROGEN PLANTS

Process	Product	Required Capital Invested per Ton of Nitrogen		Cost of Production of 1 Kg. of Fixed Nitrogen with a Cost per Kw.-Yr. of		
		Thermo-electric Energy	Hydro-electric Energy	\$20	\$15	\$10
Arc.....	Basic calcium nitrate with about 13 per cent N	\$890	\$1800	\$0.32	\$0.29	\$0.25
Cyanamide.....	Calcium cyanamide with 18-20 per cent N	293	545	\$0.16-\$0.22	\$0.15-\$0.21	\$0.14-\$0.20
Synthesis of ammonia.....	Ammonium sulphate with 20-21 per cent N	\$513		With a cost per ton of coal of \$4, and per ton of lignite of \$2.50.		
	Ammonium chloride with 20-24 per cent N	\$400-\$600				
					\$0.15	
					.12	

Ammonia from coal distillation, market price per kg., \$0.33@ \$0.35.
Chilean nitrate, market price per kg., \$0.32@ \$0.34.

Recent Chemical and Metallurgical Patents

British Patents

Complete specifications of any British patents may be obtained by remitting 25c. each to the Superintendent British Patent office, Southampton Buildings, Chancery Lane, London, England.

Purifying Graphite.—Graphite reduced to a state of fine subdivision is treated with an aqueous solution of hydrofluoric acid, with a strength of between 30 and 50 per cent, sufficient in quantity to form a mud so as to obviate the employment of an undue bulk of liquid. The strength of the acid to be used depends on the percentage of carbon desired in the purified product, since, in some cases, a high percentage is not necessary. For example, in the manufacture of pencils and parts of electro-technical apparatus, to remove the whole of the silica, the remainder is converted during the process of purification into a gelatinous form, available for use as an agglomerating agent in subsequent operations. (Br. Pat. 134,894—1919. E. RIDONI TURIN and SOC. TALCOE GRAFITI VAL CHISONE, Pinerolo, Italy; Jan. 14, 1920.)

Treatment of Tungsten Ores.—Tungsten ores are mixed with carbon and heated in dry chlorine at about 300 deg. C. Tungsten chloride or oxychloride is volatilized and condensed. The condensed chloride can be transformed easily into tungstic acid or other tungsten compound. Alternately the tungsten ore may be reduced by heating with carbon to a red heat, after which chlorine is passed over. (Br. Pat. 134,891. IMPERIAL TRUST FOR THE ENCOURAGEMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Westminster, and O. J. STAN- NARD, London; Jan. 14, 1920.)

Cementation.—Machined articles of soft iron and mild steel are coated with a metal such as nickel or cobalt and then subjected to a temperature of 1,000 to 1,200 deg. C. while protected from oxidation by a deposit or by a packing, until the nickel, etc., are absorbed by the iron or steel. Chromium and vanadium may also be used as the coating metal if the deposit thereof be protected by a deposit of iron or nickel. The packing material may be inert to the metal, or may act as a carburizer. (Br. Pat. 134,864—1919. E. H. JONES, London; Jan. 14, 1920.)

Recovering Lead and Tin.—Lead and tin are recovered from materials containing them, in the case of lead, with a treatment of hot ferric chloride solution, and in the case of tin, with hot ferric chloride or ferric sulphate solution. To the resulting solution, substan-

tially free from acid, there is added about one-third of its volume of concentrated ferrous chloride or ferrous sulphate solution, and the lead or tin is then precipitated by means of scrap iron. The deposition is preferably carried out by adding from time to time successive portions of solution to be treated to solutions from which the metal has already been deposited. (Br. Pat. 135,052—1919. W. G. RUMBOLD, London; Jan. 14, 1920.)

Potassium Chloride.—Potassium salts are recovered from blast-furnace slag by the addition of calcium chloride to the slag, in a molten state, and by collecting the volatilized potassium chloride formed. The calcium chloride is introduced from a hopper into the stream of molten slag as this flows from the furnace to the ladle. Intimate mixing takes place by having the slag flow down a cascade into a chamber from which the potassium chloride fumes escape into a condenser, where they meet a spray of water and the potassium chloride solution is collected for further use. The treated slag is said to be improved for the making of slag cement. (Br. Pat. 134,665—1919. E. BURY, O. OLANDER, T. SMITH and F. BAMBRIDGE, all of Saltburn-by-the-Sea, Yorkshire; Jan. 7, 1920.)

Magnesium Sulphate.—Magnesium sulphate is produced by heating to dull red a mixture of a magnesium-containing compound or mineral and calcium sulphide in a stream of air, water vapor and carbon dioxide. The separation of the resulting mixture of magnesium sulphate and calcium carbonate is effected by lixiviation. If the raw materials contain magnesium carbonate, the use of carbon dioxide can be dispensed with. (Br. Pat. 134,884. E. E. and P. C. DUTT, Jubbulpore, India; Jan. 14, 1920.)

Personal

Colonel WILDER D. BANCROFT, chairman of the division of chemistry, National Research Council, recently delivered a lecture at Oberlin College on colloid chemistry, and Mr. MARSH of the Hercules Powder Co. followed in the same alumni course with a lecture on high explosives.

Dr. ALLERTON S. CUSHMAN will deliver the 1920 course of lectures on "Chemistry and Civilization" under the Richard B. Westbrook Foundation at the Wagner Institute. Four lectures will be given on successive Saturday evenings, beginning March 13, at the hall of the Wagner Free Institute of Science, 17th Street and Montgomery Ave., Washington, D. C. Lectures are free to all.

J. R. DAWSON, formerly metallurgist with the American Steel & Wire Co., Worcester, Mass., has been appointed instructor in the department of metallurgy, Lehigh University, Bethlehem, Pa.

D. FRANKLIN FISHER, formerly of the U. S. Bureau of Chemistry, stationed at New York, has become research chemist for the Van Camp Packing Co., Indianapolis, Ind.

Prof. H. G. GREENISH, dean of the School of Pharmacy of the Pharmaceutical Society, London, has had conferred on him an honorary doctorate by the University of Paris.

FRANKLIN K. LANE, who retired as Secretary of the Interior on March 1, is now vice-president and legal adviser of the Mexican Petroleum Co. and the Pan-American Petroleum & Transport Co.

Dr. GRAHAM LUSK, professor of biological chemistry at Cornell Medical College, New York; Dr. LAFAYETTE B. MENDEL of Yale University, New Haven, Conn., and E. V. MCCOLLUM of Johns Hopkins University, Baltimore, Md., have been elected associate members of the Société Royale des Sciences Médicales et Naturelles de Bruxelles.

FRANK MERRICKS has been elected president of the London Institution of Mining and Metallurgy for 1920.

W. H. NICHOLS, president of the General Chemical Co., New York, has had conferred on him the degree of doctor of chemistry by the University of Pittsburgh.

Dr. A. A. NOYES has resigned from the Massachusetts Institute of Technology, to become director of chemical research at the California Institute of Technology, Pasadena, Cal.

W. A. NOYES, director of the department of chemistry of the University of Illinois, Urbana, Ill., has had conferred on him the degree of doctor of chemistry by the University of Pittsburgh.

F. K. OVITZ, superintendent of the Seattle Station, U. S. Bureau of Mines, has resigned to accept a position as fuel efficiency engineer with the Standard Oil Co. He will be located at Whiting, Ind.

G. A. RANKIN, who was with the Chemical Warfare Service at American University, has recently been made research chemist with the Geophysical Laboratory, Carnegie Institution, Washington, D. C.

F. H. RIDDLE, formerly with the Bureau of Standards at Pittsburgh, has accepted the position of director of research with the Jeffrey-Dewitt Co., Detroit, Mich.

Dr. R. E. RINDFUSZ, formerly assistant in chemistry at Oberlin College, has been appointed chief chemist to the American Writing Paper Co., at Holyoke, Mass.

Dr. WILLIAM T. SEDGWICK, head of the department of biology and public health at the Massachusetts Institute of Technology, will be the first exchange professor with the Universities of Cambridge and Leeds.

H. E. SKOUGOR has severed his connection with Guggenheim Bros., the Chile Exploration Co. and the Braden Copper Co. and has opened an office at 120 Broadway, as consulting industrial engineer.

EUGENE STEBINGER has been appointed chief of the foreign section of the Mineral Resources Branch of the U. S. Geological Survey. He has lately returned from private work in the Tampico oil fields of Mexico.

Dr. ALLEN E. STERN of the department of chemistry of the University of Illinois has resigned to become head of the division of physical chemistry at the University of West Virginia.

Dr. VICTOR C. VAUGHAN of the University of Michigan, Ann Arbor, presented a paper on Jan. 30 before the Institute of Medicine at Chicago on "The Chemistry of the Protein Molecule in Relation to Infection."

C. ERB WUENSCH, secretary of the Alumni Association of the Colorado School of Mines, has been in New York and other Eastern cities on professional business.

The American Physical Society elected the following officers at its St. Louis meeting: President, J. S. Ames; vice-president, Theodore Lyman; secretary, D. C. Miller; treasurer, G. B. Pegram; managing editor, F. Bedell; councillors, F. B. Jewett and Max Mason; members of the editorial board, E. L. Nichols, C. M. Sparrow and W. F. G. Swann.

The Southeast Texas Section of the American Chemical Society announces the election of the following officers for the year 1920: President, Dr. Felix Paquin, Galveston; vice-president, H. B. Weiser, Houston; councillor, Dr. F. W. Bushong, Port Arthur; treasurer, H. D. Draper, Houston; secretary, P. S. Tilson, Houston.

Obituary

WILLIAM J. DWYER, who established the Trade News Service, New York, died at his home in New Rochelle, N. Y., Feb. 19. Prior to entering the field on his own account, Mr. Dwyer was a member of the reportorial staff of the *Oil, Paint and Drug Reporter*.

JAMES GAYLEY, formerly vice-president of the United States Steel Corp., adviser of Andrew Carnegie in the creation of the Carnegie libraries and other Carnegie institutions presented to the public, died on Feb. 25 in his home, 555 Park Ave., New York City, after a brief illness. Mr. Gayley was sixty-five years old.

Perhaps no other individual in the world did more toward the perfection of the blast furnace than did Mr. Gayley. He had an international reputation as an inventor of steel- and iron-making apparatus; and especially did he achieve fame as the creator of the dry air blast, a refrigeration method of extracting the moisture from the blast-furnace atmosphere.

He also invented the auxiliary casting stand now used extensively in bessemer steel plants. He received the Elliot Cresson medal from Franklin Institute, Philadelphia, for inventing the dry air blast, and had been honored by many colleges and scientific institutions in the country for his achievements in the iron and steel industry.

Mr. Gayley was from his very entry into the steel-making business an intimate friend and adviser of Andrew Carnegie. He was one of the original Carnegie partners, "one of the boys who made the name Carnegie famous," as the Laird of Skibo used to say.

Mr. Gayley was born in Lock Haven, Pa., Oct. 11, 1855, a son of Rev. Dr. Samuel Alexander Gayley and Agnes G. Malcolm Gayley. After attending the public school at Lock Haven, he entered Lafayette College, where he was graduated with the engineering class of 1876, taking honors in mining and metallurgy. His first position was as chemist of the Crane Iron Co., the oldest iron-making concern in the Lehigh Valley. It was from the machine shops of the Crane Iron Co. that Captain William R. Jones, whose services to the steel industry will be remembered, graduated. Three years later Mr. Gayley became superintendent of the Missouri Furnace Co. of St. Louis. Shortly afterward he accepted the position as superintendent of furnaces at the E. & G. Brooks Iron Co., at Birdsboro, Pa.

In the fall of 1885, at the invitation of Captain Jones, Mr. Gayley accepted the position of furnace superintendent of the Edgar Thomson Steel Works at Braddock. This was the beginning of his association with Andrew Carnegie.

When Charles M. Schwab was transferred to the Homestead Steel Works Mr. Gayley was appointed general superintendent of the Edgar Thomson works, and in 1895 was transferred to the general offices in Pittsburgh to assist the late Henry M. Curry in the increasing business of the ore department. Upon the retirement of Mr. Curry from active business Mr. Gayley succeeded to the management of the ore department and also as a member of the board of managers of the Carnegie Steel Company, Ltd.

He continued with the Carnegie interests until the formation of the United States Steel Corp. in 1901, when he was made first vice-president of the Steel Corp., and had since made his headquarters in New York City. He retired from the Steel Corp. about eight years ago to devote his undivided attention to his personal interests. He was succeeded in the corporation by D. G. Kerr.

Mr. Gayley was generous toward Lafayette College. He had given approximately \$100,000 to that institution, among his gifts being a splendid chemical and metallurgical laboratory.

Mr. Gayley for many years was president and director of the American Ore Reclamation Co. He was a trustee of Lafayette College, Tome Institute, was at one time president of the board of directors of the American Institute of Mining Engineers, and was a member of the Iron and Steel Institute of Great Britain. He was a member of the following clubs: Duquesne, Metropolitan, University, Engineers, Oakland, Golf, Bankers, Automobile of America and the Society of St. Andrew's and the Pilgrims of the United States.

Dr. S. MACKAY, professor of chemistry at Dalhousie University, died of pneumonia at Halifax, N. S., on Jan. 6. He was born in Nova Scotia in 1864.

JAMES P. REILLY of The Barrett Co., New York, died recently at his home at Germantown, Pa. Death was caused from hemorrhage of the brain from an attack which occurred two weeks before his death and which, it is believed, is traceable to overwork during the war when he was chairman of a chemical board, with headquarters in Washington. Prior to his last illness, Mr. Reilly had never known a sick day in his life. He was born in Ireland

forty-three years ago, and was educated in England. As a youth he came to Philadelphia. He had been connected with The Barrett Co. for many years. He leaves a widow, Mrs. Minnie McKey Reilly, a daughter and three sons.

Dr. EDWIN A. STRONG, professor emeritus of physics at the Michigan State Normal College, died Feb. 4 at the age of eighty-six.

RALSTON C. WARE, president of Ware Bros. Co., Philadelphia, publishers of *American Fertilizer* and other trade journals, was stricken with pneumonia and died Wednesday, Feb. 4, at the age of sixty.

HERBERT SPENCER WOODS, professor of biological chemistry at the University of Texas, died at Dallas on Jan. 4, following an operation. He was thirty-six years of age.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 1.—There has been little change since last week's report. Tin, lead and mercury advanced, while zinc and silver declined slightly.

	Cents per Lb.
Copper, electrolytic.....	19.00
Aluminum, 98 to 99 per cent.....	33.00
Antimony, wholesale lots.....	12.00
Nickel, ordinary.....	43.00
Nickel, electrolytic.....	45.00
Tin, Straits, spot.....	64.50
Lead, New York, spot.....	9.00
Lead, E. St. Louis, spot.....	8.37½
Zinc, spot, New York.....	9.30
Zinc, spot, E. St. Louis.....	9.00
Silver.....oz.	\$1.29½
Cadmium.....lb.	1.50
Cobalt.....lb.	1.50
Platinum.....oz.	150.00
Iridium.....oz.	250.00
Palladium.....oz.	150.00
Mercury.....75 lb.	90@92

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled.....	29.50
Copper sheets, cold rolled (over 14 oz.).....	31.50
Copper bottoms.....	38.00
Copper rods.....	27.50
High brass wire and sheets.....	26.50
High brass rods.....	23.75
Low brass wire and sheets.....	28.50
Low brass rods.....	29.25
Brazed brass tubing.....	38.25
Brazed bronze tubing.....	43.00
Seamless copper tubing.....	33.50
Seamless bronze tubing.....	34.50
Seamless brass tubing.....	32.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap.....	23½@24½
Aluminum, sheet scrap.....	22½@23½
Aluminum clippings.....	25½@27
Copper, heavy machinery comp.....	14½@14
Copper, heavy and wire.....	13½@14
Copper, light and bottoms.....	12½@12½
Copper, heavy cut and crucible.....	11½@12
Brass, heavy.....	11½@12
Brass, casting.....	10½@10½
Brass, light.....	9@9½
No. 1 clean brass turnings.....	9½@10
No. 1 comp. turnings.....	12@12½
Lead, tea.....	5½@5½
Lead, heavy.....	6@6½
Zinc, scrap.....	6@6½

Chemical and Allied Industrial Markets

New York, February 27, 1920.

Continued firmness characterized the chemical market during the past week, there being but few changes of importance. Demand in the spot market is still brisk and small supplies are the only drawback. Unfavorable rate of exchange has slightly affected exporting in some lines, but caustic soda still tops the list and is under heavy foreign inquiry.

HEAVY CHEMICALS

White sal ammoniac remains steady, with a slight upward tendency, 15@16c. per lb. being the listing on carlots, while in less than carlots it is quoted at 16@18c. Barium chloride has been very active and quotations vary greatly, \$100 per ton being the lowest and \$130 the highest. There is very little of this material on the spot market and producers

are pushed to the limit to meet their contracts. The export demand has fallen off slightly on *caustic potash*, while domestic demand continues firm. The last price of 28@32c. is still maintained.

Soda ash is practically off the spot market. Sales have been reported on the light at \$2.50@\$2.60 per cwt., while \$2.70@\$2.75 is being asked for the dense. Foreign demand remains unaltered despite the low rate of exchange. *Cobalt oxide* has been advanced from \$1.50@\$1.55 per lb. to \$2@\$2.05. This change went into effect the early part of last week. *Niter cake* is very scarce and the price still remains firm at \$7.@\$7.50 per ton. There has been a tightening in *sal soda* during the past week, with the price of \$1.35@\$1.40 per cwt. remaining firm. *Oxalic*, crystals, has advanced during the past week and as high as 46c. per lb. is being asked for spot material, but the average price ranges from 40@42c. per lb. A slight tightening of supplies has been felt in *sulphuric*, 66 deg., which remains firm at \$22 per ton.

COAL-TAR PRODUCTS

The coal-tar products market remains practically unchanged, although it is reported that producers are not being pushed as hard as they were a few weeks ago, but as yet this has not affected the spot market. *Dimethyl-aniline* continues scarce owing to the lack of methyl alcohol. Quotations range from 95c.@\$1.20 per lb. *H acid* is practically unobtainable either on spot or contracts. The price of \$1.60@\$1.75 per lb. remains firm. *Phthalic anhydride* has picked up slightly and is now being offered at 60@70c. per lb. The spot market on *benzol* is rather tight. Producers are supplying contract orders at 25c. per gal. *Alpha naphthol* continues scarce, there being very little material available on spot. Crude is quoted at \$1@\$1.10 per lb., while refined is listed at \$1.40@\$1.60 per lb.

NAVAL STORES

There has been a gradual decline in this market lately, due principally to the unfavorable rate of exchange. England has fallen below her previous large buying business in this country. The coming spring painting campaign is expected to put *turpentine* back in its recently high position. Present quotation on spirits of turpentine is about \$1.93 per gal., as compared with \$2.05 a few weeks ago. *Rosins* have dropped in all grades due to a falling off of foreign inquiry.

CRUDE RUBBER

Evidently the bottom has not been reached in the crude rubber market, as prices continue steadily on the decline. Buyers are anticipating a still lower level and are not very active beyond their actual present needs. The continued low rate of exchange is responsible for the low price level now existing in this market.

OILS

An easier market in practically all lines in oils is the report of the past week. *Cottonseed* continues on the decline and is quoted as low as 18½c. per lb. *Soya bean* remains quiet with a slight drop from 17½c. to 16½c. per lb. *Linseed* has been firmly maintained and it is pointed out by some that a drop in this item will occur before the spring buying season opens.

MISCELLANEOUS MATERIALS

The future market in *barytes* is still indefinite as to price. Producers' quotations are from month to month. Demand on this item remains brisk and plants are being worked to their limit in order to meet contracts. The present quotation holds firm at \$35@\$40 per ton. Quotations on *feldspar* are still nominal at \$13.50@\$18 per ton with great difficulty in locating any material even at the latter price.

Chicago, February 25, 1920.

Strong markets in all lines prevail, with production apparently not able to keep up with demand. Pressure of export business continues on alkalis, and prices in these items have been forced up another notch. Actual trading

is light in all lines except alkalis, apparently because consumers refuse to buy anything beyond current needs.

HEAVY CHEMICALS

Methyl alcohol is almost unobtainable, offers ranging from \$2.25@\$2.50 per gal. for 95 per cent grade. Owing to scarcity of the product, actual sales are few and for small quantities. *Ethyl* grade seems to be a little freer, some business being done at \$5.35@\$5.70 for 190 proof, in bbl. Production is so far behind spot demand that no orders for later delivery are being taken. *Formaldehyde* remains firm at 48@50c., with the severe shortage formerly noted still effective, with practically no future delivery contracts being placed.

On continued Eastern demand for export shipment *caustic soda* is again up, price for the solid being around \$4.25 per cwt. in cars, f.o.b. works, and for the granulated \$4.50@\$4.75, with the latter figure ruling today. These figures represent an advance of from 35@50c. per cwt. since last reported. *Bleaching powder* remains stationary at \$3 per cwt., f.o.b. works, in carload lots. Similar conditions have pushed the price of *soda ash* up 15c., with today's quotation \$2.25 per cwt. Accurate quotations on *sodium bichromate* are impossible, transactions in small quantities having been closed during the past two weeks at 35@45c. per lb. It is offered today at 40c.

Acids show no important change. Demand is light, but production is so nearly completely under contract as to preclude any drop in prices. Current quotations are: *Sulphuric*, 66 deg., \$22 per ton in cars; *muratic*, 22 deg., \$2.50@\$2.62½ per cwt.; *nitric*, 42 deg., \$7.25 per cwt., and *oxalic*, 40@42c. per lb. in bbl.

COAL-TAR PRODUCTS

This market remains firm in all lines, producers holding the current high figures and buyers reluctant to do much trading. As production is gradually getting better, it seems that somewhat lower prices may soon prevail. *Benzol* and *toluol* stand at 27c. and 28c. respectively in large quantities from refiners. Spot business is very light and is at a slight advance over these quotations. In the acids no change is noted, *picric* being quoted at 25c. per lb., *benzoic* at 75c. for technical grade and *salicylic* at 44c. for technical grade. *Aniline oil* at 34c. and *aniline salts* at 44c. show no change, supply being very light and but little demand being felt at these high prices.

VEGETABLE OILS

Quietness prevails throughout this line, no changes of moment having occurred for some time. Current quotations for *linseed oil* in bbl. are \$1.98 per gal., in cars, \$1.75@\$1.80 per gal.; *cocoanut oil*, miller grade, in bbl., 19c. per lb.; *soya bean oil*, 18@19c. in bbl.; *corn oil*, prime, in tanks, 19@20c.; *cottonseed oil*, crude, in bbl., 18½c., prime summer yellow, in bbl., 23@23½c. These quotations are all f.o.b. Chicago.

FLOTATION OILS; NAVAL STORES

Foreign demand for *turpentine* has ceased for the present, and the domestic trade seems unwilling to pay such high prices, hence price is off from a quotation of \$2.16 per gal. a few days ago to \$1.96 per gal. today. With the new crop an unknown quantity, trading is apt to remain light. Acute shortage keeps pine oil up to its previous high mark of \$1.50 for both pure and destructively distilled. Conditions affecting *turpentine* also prevail in trading in *rosin* as a result of which prices have receded. Present quotation on *F* grade is \$18.80 and on *WW* is \$22@\$22.50.

FERTILIZERS

There is no change in prices in this market. As buyers seem to feel that conditions justify their expectation of lower prices soon, but little actual trading is being done. Last quotations were: *Ground blood*, \$8; *unground blood*, \$7.80; *high-grade ground tankage*, \$7.65; *bone meal*, in carloads, f.o.b. Chicago, \$46.50 per ton.

The Iron and Steel Market

Pittsburgh, February 28, 1920.

The iron and steel market has been the subject of conflicting emotions. While it may be the case sometimes that the market is controlled by actual physical conditions as to supplies and requirements, it has not infrequently been the case that the actual market has been dictated largely by men's feelings or emotions. In times of relatively slack demand for steel the consumer has underrated his prospective requirements and has had an undue feeling of security about the certainty of prompt deliveries in future, while in times of slight scarcity he has frequently been unduly alarmed and has sought to buy in excess of his real requirements.

Set in juxtaposition, two incidents of the past week are illustrative of the psychological aspect of the market just referred to. About three weeks ago sheet bars sold at the new record high price of \$65, the buyers being automobile interests intending to have the bars converted into sheets under conversion contracts at sheet mills. Such conversion contracts have been easy to make with some sheet mills, on account of their being short of steel and thus having idle rolling-mill capacity. Even the Steel Corporation subsidiary has been quite ready to make such contracts in some cases, at quite moderate charge for the conversion. Last week sheet bars similarly brought \$70. This week there were two sales, one of 1,000 tons of open-hearth at \$80, and another of 1,500 tons of bessemer at \$75. The item to be set in opposition to this feverish buying at sharply advancing prices is that a pig-iron producer has just sold a round tonnage of basic pig iron for early delivery on the basis of \$41.50, valley, when previously the market had been pushed up by actual purchases to \$43 and for a time had been well established at that figure as minimum for any delivery.

MARKET ABANDONING RUNAWAY DISPOSITION

Further illustrating the market's tendency to abandon its disposition toward a runaway, either through discovery of an inability in the market to run very fast or far, or from an accretion of conservatism dictated by sober second thought on the part of producers, it is to be related that several large independents, hitherto practically out of the market, have set relatively moderate prices at which they will cover their customers for second quarter delivery, these prices being 3c. and 3.10c. for bars and shapes respectively, \$2 a ton above the war control prices and \$13 a ton above the March 21 or Industrial Board prices, still rigidly adhered to by the Steel Corporation, and 3.25c. to 3.50c. for plates, comparing with 3.25c. under the war control price and 2.65c. by the March 21 schedule.

It should be particularly noted that these prices are set for settlement of second quarter deliveries, because curious statements have been appearing in the financial press to the effect that the independent steel producers are sold up far ahead, hence "rumors from Pittsburgh" that the steel market is less strong than had been imagined do not mean anything. Nothing could be further from the truth than to assert that the independents at this time are unusually well sold up. On the contrary, they have unusually light order books, for a period of apparently heavy demand. This arises from the fact that the class of mills that have been seeking fancy prices could obtain them only for early deliveries while those who pursued the pseudo-conservative policy of staying out of the market and not naming prices at all have naturally not been making sales. They have by promise to customers reserved large tonnages to be furnished at prices to be named later, some of these prices having been named in the past few days, as related above, but such operations constitute an obligation on the part of sellers, not an obligation on the part of buyers.

REVOLT AGAINST AUTOMOBILE STEEL PRICE DICTATION

A feature of the general steel market situation is the growing revolt among steel consumers against automobile trade dictation of prices. The automobile trade has been bidding fancier and fancier prices for prompt lots of steel products, as well as for various other materials, including

lumber, plate glass, etc., and buyers of such commodities find that the pace set is one that simply cannot be followed by the manufacturers of such commonplace articles as agricultural implements, hardware, freight cars and locomotives. There is a growing disposition to reflect that the automobile trade, no matter how much money it may perhaps have at its disposal, does not and cannot consume the bulk of the production in any important commodity. In steel, for instance, while its consumption has not been estimated closely, the quantity can hardly be a quarter million gross tons of finished rolled steel a month, while the steel industry's capacity is in excess of three million gross tons a month.

TRANSPORTATION CONDITIONS UNIMPROVED

On the whole transportation conditions as affecting the iron and steel industry have not improved. Coal operators claim their car shortage is greater than ever. Car supplies in the Connellsville region have been better this week than last, but were poorer last week than the average of several weeks preceding. On a general average the supply of cars for moving finished steel from mill may have improved somewhat. One very favorable item is that the Carnegie Steel Co., which four weeks ago had between 150,000 and 160,000 tons piled at its various plants awaiting shipment, has now cut the accumulation in half. On the other hand, the American Sheet & Tin Plate Co.'s accumulation has grown until it amounts to about 50,000 tons, or approximately ten days of normal production. A third aspect is presented by another subsidiary of the Steel Corporation, the National Tube Co., which has operated at fully 90 per cent of capacity since the first of the year, and has been able to ship its product as fast as made.

From these and other considerations a generalization may be hazarded that car shortages are a local matter, depending chiefly upon the terminal and other facilities in various districts. From this, furthermore, it may be inferred, as many railroad men have asserted, that what the railroads need is not so much cars and locomotives as additional terminal and siding facilities, and probably more block signalling. There is, however, a moderate volume of freight car inquiry in the market, and buying in the next few months may aggregate several tens of thousands of cars. Assertions sometimes encountered setting immediate railroad needs in terms of hundreds of thousands of cars may well be ignored.

PIG IRON

As noted above, basic pig iron has sold at \$41.50, valley basis, against a previously established market of \$43. Bessemer remains at \$42, valley, and can easily be had for prompt shipment at this figure. Foundry remains at \$42, valley, for extended delivery, with doubt whether much premium would have to be paid for prompt. Throughout the local market inquiry is very light, and some recent purchases were of smaller tonnages than the buyers originally contemplated.

STEEL

Sheet bars have sold at up to \$80, as reported above, and it is uncertain at what prices mills will cover regular customers for additional tonnages. Billets have been in light demand and correspondingly light supply, being quotable perhaps at \$55 to \$60.

FERRO-ALLOYS

There seems to be a scarcity of prompt ferromanganese, with sales of small lots reported at over \$200. Furnaces continue to quote \$160, delivered, for second half, but it is possible this might be shaded to \$150. English is about \$150, c.i.f. Spiegeleisen is held at \$57 to \$60, furnace, for futures.

Electrolytic ferrosilicon, 50 per cent, remains at \$80, delivered, but one or two makers have just advanced to \$85, while 75 per cent remains at \$140, delivered. Bessemer ferrosilicon remains at last week's price of \$59.50 for 10 per cent, \$62.80 for 11 per cent and \$66.10 for 12 per cent, f.o.b. Jackson, Ohio.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....lb.		\$0.60 - \$0.65
Acetone.....lb.	\$0.16 - \$0.20	21 - 25
Acid, acetic, 28 per cent.....cwt.	2.75 - 3.00	3.00 - 3.25
Acetic, 56 per cent.....cwt.	5.25 - 5.75	6.00 - 6.50
Acetic, glacial, 99½ per cent, carboys.....cwt.	12.00 - 12.50	13.50 - 15.50
Boric, crystals.....lb.	14½ - 15½	15½ - 16½
Boric, powder.....lb.	14½ - 15	15 - 16
Hydrochloric.....lb.	08 - 15	09 - 10
Hydrofluoric, 52 per cent.....lb.	12 - 12½	14 - 16
Lactic, 44 per cent tech.....lb.	11 - 11½	12 - 16
Lactic, 22 per cent tech.....lb.	05 - 06	05½ - 07
Molybdenic, C. P.....lb.		4.25 - 5.00
Nitric, 40 deg.....lb.	06 - 07	07½ - 08½
Nitric, 42 deg.....lb.	06½ - 07	08 - 09½
Oxalic, crystals.....lb.	35 - 40	40 - 46
Phosphoric, Ortho, 50 per cent solution.....lb.	24 - 35	40 - 50
Picric.....lb.	30 - 35	40 - 50
Pyrogallol, resublimed.....lb.	2.50 - 2.55	2.60 - 2.65
Sulphuric, 60 deg., tank cars.....ton	17.50 - 22.00	
Sulphuric, 60 deg., drums.....ton	22.00 - 25.00	
Sulphuric, 66 deg., tank cars.....ton		
Sulphuric, 66 deg., drums.....ton		
Sulphuric, 66 deg., carboys.....ton		
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	27.00 - 30.00	32.00 -
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	32.00 -	34.00 -
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	35.00 -	40.00 -
Tannic, U. S. P.....lb.		1.35 - 1.45
Tannic (tech.).....lb.		42 - 55
Tartaric, crystals.....lb.		69 - 74
Tungstic, per lb. of WO.....lb.		1.20 - 1.40
*Alcohol, Ethyl.....gal.	4.80 - 5.50	6.00 - 7.00
*Alcohol, Methyl.....gal.	1.50 -	1.52 - 1.57
*Alcohol, denatured, 188 proof.....gal.		65 - 78
*Alcohol, denatured, 190 proof.....gal.		67 - 74
Alum, ammonia lump.....lb.	04½ - 05	05½ - 06
Alum, potash lump.....lb.	08 - 08½	09 - 09½
Alum, chrome lump.....lb.	15 - 16	18 - 20
Aluminum sulphate, commercial.....lb.	01½ - 02	02½ - 03
Aluminum sulphate, iron free.....lb.	02½ - 03	03½ - 04
Aqua ammonia, 26 deg., drums (750 lb.).....lb.	08½ - 10½	11 - 12
Ammonia, anhydrous, cylinders (100-150 lb.).....lb.	33 - 35	35 - 37
Ammonium carbonate, powder.....lb.	13 - 16½	17 - 17½
Ammonium chloride, granular (white sal-ammoniac).....lb.	15 - 16	16 - 18
Ammonium chloride, granular (gray sal-ammoniac).....lb.	13 - 13½	14 - 14½
Ammonium nitrate.....lb.	10 - 12	06 -
Ammonium sulphate.....lb.	05 -	3.65 - 3.75
Amylacetate.....gal.		10½ - 11
Arsenic, oxide, lumps (white arsenic).....lb.	23 - 24	
Arsenic, sulphide, powdered (red arsenic).....lb.	100.00 - 105.00	110.00 - 130.00
Barium chloride.....lb.	26 - 27	28 - 30
Barium dioxide (peroxide).....lb.	11 - 12	13 - 14
Barium nitrate.....lb.	03 - 03½	05½ - 06
Barium sulphate (precip.) (blanc fixe).....lb.		
Bleaching powder (see calcium hypochlorite).....lb.		
Blue vitriol (see copper sulphate).....lb.		
Borax (see sodium borate).....lb.		
Brimstone (see sulphur, roll).....lb.	90 - 95	
Bromine.....lb.	2.00 - 2.05	2.10 -
Calcium acetate.....cwt.		04½ - 05
Calcium carbide.....lb.	20.00 - 25.00	30.00 - 40.00
Calcium chloride, fused, lump.....ton	01½ - 01½	02 - 02½
Calcium chloride, granulated.....cwt.		4.00 - 4.50
Calcium hypochlorite (bleaching powder).....cwt.	3.50 -	1.50 - 1.70
Calcium peroxide.....lb.		75 - 80
Calcium phosphate, monobasic.....lb.	08 - 08½	25 - 30
Calcium sulphate, pure.....lb.	06 - 08	09 - 10
Carbon bisulphide.....lb.	10½ - 11	12 - 15½
Carbon tetrachloride, drums.....lb.		80 - 1.05
Carbonyl chloride (phosgene).....lb.		
Caustic potash (see potassium hydroxide).....lb.		
Caustic soda (see sodium hydroxide).....lb.	05 - 05½	08 -
Chlorine, gas, liquid-cylinders (100 lb.).....lb.	28 - 29	30 - 31
Chloroform.....lb.		2.00 - 2.05
Cobalt oxide.....lb.		
Copperas (see iron sulphate).....lb.		29 - 31
Copper carbonate, green precipitate.....lb.	27 - 28	65 - 70
Copper cyanide.....lb.	08½ - 09	09 - 09½
Copper sulphate, crystals.....lb.		
Cream of tartar (see potassium bitartrate).....lb.		3.00 - 3.25
Epsom salt (see magnesium sulphate).....lb.		45 - 65
Formaldehyde, 40 per cent.....lb.		
Glauber's salt (see sodium sulphate).....lb.		24½ - 26
Glycerine.....lb.		4.10 - 4.30
Iodine, resublimed.....lb.		03 - 20
Iron oxide, red.....lb.	1.20 -	1.25 - 1.75
Iron sulphate (copperas).....cwt.	12 - 13	14 - 23
Lead acetate, normal.....lb.		13 - 17
Lead arsenate (paste).....lb.		70 - 80
Lead nitrate, crystals.....lb.	11½ - 12½	12½ - 13
Litharge.....lb.		1.50 - 1.75
Lithium carbonate.....lb.		13 - 14½
Magnesium carbonate, technical.....lb.		2.75 - 3.25
Magnesium sulphate, U. S. P.....100 lb.	2.15 - 2.63	2.00 - 2.50
Magnesium sulphate, commercial.....100 lb.	1.75 -	15 -
Nickel salt, double.....lb.	14 -	17 -
Nickel salt, single.....lb.	12½ - 13	
Phosgene (see carbonyl chloride).....lb.		60 - 65
Phosphorus, red.....lb.		35 - 37
Phosphorus, yellow.....lb.		34 - 37
Potassium bichromate.....lb.	32 - 33	56 - 60
Potassium bitartrate (cream of Tartar).....lb.		50 - 65
Potassium bromide, granular.....lb.		65 - 70
Potassium carbonate, U. S. P.....lb.	60 - 27	28 - 30
Potassium carbonate, crude.....lb.	16 - 20	21 -
Potassium chlorate, crystals.....lb.	28 - 32	35 - 42
Potassium hydroxide (caustic potash).....lb.		3.35 - 3.60
Potassium iodide.....lb.	19 -	21 -
Potassium nitrate.....lb.		30.65 - 30.95
Potassium permanganate.....lb.		

Nominal quotations.

	Carlots	Less Carlots
Potassium prussiate, red.....lb.	1.00 - 1.05	1.10 - 1.20
Potassium prussiate, yellow.....lb.		.40 - .70
Potassium sulphate.....ton	\$225.00 -	
Rochelle salts (see sodium potas. tartrate).....lb.		
Salammoniac (see ammonium chloride).....lb.		
Salt soda (see sodium carbonate).....lb.		
Salt cake (see sodium sulphate).....ton	18.00 - 21.00	
Silver cyanide.....oz.		1.25 -
Silver nitrate.....oz.		81½ - 82½
Soda ash, light.....100 lb.	2.50 - 2.60	
Soda ash, dense.....100 lb.	2.70 - 2.75	
Sodium acetate.....lb.	.06½ - .07	.07 - .08
Sodium bicarbonate.....100 lb.	2.40 -	2.75 - 3.00
Sodium bichromate.....lb.	.33 - .34	.35 - .36
Sodium bisulphate (nitre cake).....ton	7.00 - 7.50	8.00 - 10.00
Sodium bisulphite.....cwt.	5.00 - 6.00	6.50 - 7.00
Sodium borate (borax).....lb.	.08½ - .08½	.09 -
Sodium carbonate (sal soda).....100 lb.	1.35 - 1.40	1.50 - 1.75
Sodium chlorate.....lb.	.10 -	.12 - .14
Sodium cyanide, 96-98 per cent.....lb.	.30 -	.31 - .34
Sodium fluoride.....lb.	.14 -	.15 - .16
Sodium hydroxide (caustic soda).....100 lb.		4.85 - 5.25
Sodium hyposulphite.....lb.		.03½ - .04
Sodium molybdate.....lb.	2.50 -	3.25 -
Sodium nitrate.....100 lb.	3.00 - 3.25	3.75 - 4.00
Sodium nitrite.....lb.	.15 - .17	.18 -
Sodium peroxide, powdered.....lb.		.30 - .32
Sodium phosphate, dibasic.....lb.	.03½ - .04½	.04½ - .05
Sodium potassium tartrate (Rochelle salts).....lb.	.40 - .42	.43 - .45½
Sodium prussiate, yellow.....lb.	.23 - .29	.30 - .40
Sodium silicate, solution (40 deg.).....lb.	.01½ - .02	.02 - .02½
Sodium silicate, solution (60 deg.).....lb.	.02½ - .03	.05 - .06
Sodium sulphate, crystals (Glauber's salt).....cwt.	1.15 - 1.50	1.60 - 2.00
Sodium sulphide, crystal, 60-62 per cent (conc).....lb.		.05 - .06
Sodium sulphite, crystals.....lb.	.03½ -	.04 - .06
Strontium nitrate, crystals.....lb.	.25 -	.28 -
Sulphur chloride, crystals.....lb.	.05½ -	.06 -
Sulphur, crude.....ton	22.00 -	
Sulphur dioxide, liquid, cylinders.....lb.	.09 -	.10 - .12
Sulphur (sublimed), flour.....100 lb.	3.35 -	3.40 - 3.65
Sulphur, roll (brimstone).....100 lb.	3.20 -	3.30 - 3.40
Tin bichloride (stannous).....lb.	.42½ -	.46 - .50
Tin oxide.....lb.	.50 - .60	.65 -
Zinc carbonate, precipitate.....lb.		.20 -
Zinc chloride, gran.....lb.	.13 -	.13½ - .15
Zinc cyanide.....lb.	.49 -	.50 -
Zinc dust.....lb.	.11½ - .12½	.13 - .15
Zinc oxide, dry American.....lb.		.09½ - .12
Zinc sulphate.....lb.	.03½ - .03½	.04 - .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude.....lb.	\$1.00 - \$1.10
Alpha naphthol, refined.....lb.	1.40 - 1.60
Alpha naphthylamine.....lb.	.40 - .50
Aniline oil, drums extra.....lb.	.34 - .45
Aniline salts.....lb.	.42 - .50
Anthracic, 80% in drums (100 lb.).....lb.	.75 - 1.00
Benzaldehyde (f.f.c.).....lb.	2.00 - 2.10
Benzidine, base.....lb.	1.05 - 1.25
Benzidine, sulphate.....lb.	.90 - 1.00
Benzoic acid, U. S. P.....lb.	.90 - 1.10
Benzoate of soda, U. S. P.....lb.	.80 - 1.00
Benzol, pure, water-white, in drums (100 lb.).....gal.	.27 - .36
Benzol, 90% in drums (100 lb.).....gal.	.25 - .29
Benzyl chloride, 95-97%, refined.....lb.	.35 - .40
Benzyl chloride, tech.....lb.	.25 - .35
Beta naphthol benzoate.....lb.	.50 - .55
Beta naphthol, sublimed.....lb.	.65 - .80
Beta naphthol, tech.....lb.	.45 - .55
Beta naphthylamine, sublimed.....lb.	2.25 - 2.35
Cresol, U. S. P., in drums (100 lb.).....lb.	.16 - .18
Ortho-cresol, in drums (100 lb.).....lb.	.23 - .25
Cresylic acid, 97-99%, straw color, in drums.....gal.	.95 - 1.10
Cresylic acid, 95-97%, dark, in drums.....gal.	.85 - 1.00
Cresylic acid, 50%, first quality, drums.....gal.	.60 - .70
Dichlorobenzol.....lb.	.07 - .10
Diethylaniline.....lb.	1.40 - 1.50
Dimethylaniline.....lb.	.95 - 1.20
Dinitrobenzol.....lb.	.26 - .37
Dinitrochlorobenzol.....lb.	.25 - .30
Dinitronaphthalene.....lb.	.45 - .55
Dinitrophenol.....lb.	.32 - .36
Dinitrotoluol.....lb.	.38 - .45
Dip oil, 25%, tar acids, car lots, in drums.....gal.	.38 - .40
Diphenylamine.....lb.	.55 - .65
H-acid.....lb.	1.60 - 1.75
Metaphenylenediamine.....lb.	1.15 - 1.80
Monochlorobenzol.....lb.	.12 - .15
Monothylaniline.....lb.	1.50 - 1.75
Naphthalene crushed, in bbls. (250 lb.).....lb.	.06 - .08
Naphthalene, flake.....lb.	.07 - .08
Naphthalene, balls.....lb.	.08½ - .10
Naphthionic acid, crude.....lb.	.75 - 1.25
Nitrobenzol.....lb.	.14 - .19
Nitro-naphthalene.....lb.	.30 - .35
Nitro-toluol.....lb.	.20 - .30
Ortho-amidophenol.....lb.	3.75 - 4.25
Ortho-dichlor-benzol.....lb.	.15 - .20
Ortho-nitro-phenol.....lb.	.80 - 1.25
Ortho-nitro-toluol.....lb.	.25 - .40
Ortho-toluidine.....lb.	.25 - .45
Para-amidophenol, base.....lb.	2.50 - 3.50
Para-amidophenol, HCl.....lb.	2.50 - 3.25
Para-dichlor-benzol.....lb.	.12 - .18
Paranitraniline.....lb.	1.00 - 1.35
Para-nitro-toluol.....lb.	1.35 - 1.50
Paraphenylenediamine.....lb.	2.15 - 3.00
Paratoluidine.....lb.	1.75 - 2.50
Phthalic anhydride.....lb.	.60 - .70
Phenol, U. S. P., drums (dest.), (240 lb.).....lb.	.12 - .25
Pyridin.....gal.	2.00 - 2.50
Resorcin, technical.....lb.	3.75 - 4.50
Resorcin, pure.....lb.	6.50 - 6.75
Salicylic acid, tech., in bbls. (110 lb.).....lb.	.43 - .45
Salicylic acid, U. S. P.....lb.	.55 - .60
Salol.....lb.	.90 - .95

Solvent naphtha, water-white, in drums, 100 gal.	gal.	\$0.22	—	\$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.32
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.45
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	\$0.42	—	\$0.45
Beeswax, refined, yellow	lb.	.47	—	.48
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1	lb.	.80	—	.88
Carnauba, No. 2, regular	lb.	.65	—	.78
Carnauba, No. 3, North Country	lb.	.46	—	.48
Japan	lb.	.184	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	—	—	.074
Paraffine waxes, crude, scale 124-126 m.p.	lb.	—	—	.074
Paraffine waxes, refined, 118-120 m.p.	lb.	—	—	.104
Paraffine waxes, refined, 128-130 m.p.	lb.	.094	—	.104
Paraffine waxes, refined, 133-135 m.p.	lb.	—	—	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	—	—	.14
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr. 0.930-0.940	gal.	\$1.45	—	—
Pine oil, pure, dest. dist.	gal.	—	—	.40
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	—	—	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	—	—	.70
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	—	—	.38
Pine tar, ref., thin, sp. gr. 1.080-1.960	gal.	—	—	1.60
Turpentine, crude, sp. gr. 0.900-0.970	gal.	—	—	.35
Hardwood oil, f.o.b. Mich., sp. gr. 0.960-0.990	gal.	—	—	.52
Pinewood creosote, ref.	gal.	—	—	—

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	\$17.00	—	\$18.50
Rosin E-I	280 lb.	18.05	—	18.75
Rosin K-N	280 lb.	18.50	—	21.50
Rosin W. G. W. W.	280 lb.	21.50	—	24.25
Wood rosin, bbl.	280 lb.	15.50	—	17.50
Spirits of turpentine	gal.	—	—	1.93
Wood turpentine, steam dist.	gal.	—	—	1.93
Wood turpentine, dest. dist.	gal.	—	—	1.85
Pine tar pitch, bbl.	200 lb.	8.50	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	14.75
Retort tar, bbl.	500 lb.	15.00	—	15.25
Rosin oil, first run	gal.	.93	—	.95
Rosin oil, second run	gal.	.96	—	.97
Rosin oil, third run	gal.	1.10	—	1.15
Rosin oil, fourth run	gal.	—	—	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	\$0.334	—	—
70-72 deg., steel bbls. (85 lb.)	gal.	—	—	.314
68-70 deg., steel bbls. (85 lb.)	gal.	—	—	.304
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	—	—	.234

Crude Rubber

Para-Upriver fine	lb.	\$0.424	—	\$0.44
Upriver coarse	lb.	.314	—	.35
Upriver cauchó ball	lb.	.314	—	.344
Plantation—First latex crepe	lb.	.464	—	.49
Ribbed smoked sheets	lb.	.46	—	.48
Brown crepe, thin, clean	lb.	.41	—	.43
Amber crepe No. 1	lb.	.45	—	—

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	\$0.18	—	\$0.19
Castor oil, AA, in bbls.	lb.	.214	—	.23
China wood oil, in bbls.	lb.	.234	—	.254
Cocanut oil, Ceylon grade, in bbls.	lb.	.184	—	.194
Cocanut oil, Cochín grade, in bbls.	lb.	.204	—	.23
Corn oil, crude, in bbls.	lb.	.19	—	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.184	—	.20
Cottonseed oil, summer yellow	lb.	.22	—	.27
Cottonseed oil, winter yellow	lb.	.244	—	.254
Linseed oil, raw, car lots	gal.	1.65	—	1.68
Linseed oil, raw, tank cars	gal.	1.60	—	1.62
Linseed oil, boiled, car lots	gal.	1.70	—	1.75
Olive oil, commercial	gal.	2.50	—	3.00
Palm, Lagos	lb.	.164	—	.164
Palm, bright red	lb.	.154	—	.174
Palm, Niger	lb.	.16	—	.174
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.224	—	.24
Peanut oil, refined, in bbls.	lb.	.27	—	.28
Rapeseed oil, refined in bbls.	gal.	1.45	—	1.68
Rapeseed oil, blown, in bbls.	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.184	—	.23
Soya bean oil, tank cars, f.o.b. Pacific coast	lb.	.164	—	.20

FISH

Winter pressed Menhaden	gal.	\$1.20	—	—
Yellow bleached Menhaden	gal.	1.18	—	—
White bleached Menhaden	gal.	1.20	—	—
Blown Menhaden	gal.	1.26	—	—

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	\$35.00	—	\$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.044	—	.054
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.044	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	13.50	—	18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00	—	45.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	50.00	—	52.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	—	—	.074
Graphite, crucible, 86% carbon content	lb.	—	—	.07
Graphite, crucible, 87% carbon content	lb.	—	—	.07
Graphite, crucible, 88% carbon content	lb.	—	—	.08
Graphite, crucible, 89% carbon content	lb.	—	—	.084
Graphite, crucible, 90% carbon content	lb.	—	—	.08
Graphite, crucible, 91% carbon content	lb.	—	—	.084
Graphite, crucible, 92% carbon content	lb.	—	—	.09
Graphite, crucible, plus 92%	lb.	—	—	.12
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.024	—	—
Shellac, orange, fine	nominal lb.	1.55	—	1.60
Shellac, orange, superfine	lb.	1.65	—	1.70
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4 1/2 x 2 1/2 in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	\$200.00	—	\$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.50
Ferro-manganese, 70-80% Mn.	gross ton	160.00	—	170.00
Spiegeleisen, 16-20% Mn.	gross ton	54.00	—	60.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.50	—	2.75
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25	—	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00	—	—
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50	—	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr ₂ O ₃	unit	\$0.60	—	\$1.80
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00	—	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	—	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	—	—	25.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO ₂)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂	lb.	.75	—	.50
Tungsten, Scheelite, 60% WO ₃ and over, per unit of WO ₃	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO ₃ and over, per unit of WO ₃	unit	7.50	—	10.00
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	—
Pyrites, foreign, lump	unit	.17	—	—
Pyrites, foreign, fine	unit	.17	—	—
Pyrites, domestic, fine	unit	.16	—	.17
Ilmenite, 52% TiO ₂	lb.	.02	—	—
Rutile, 95% TiO ₂	lb.	.11	—	—
Carnotite, minimum 2% U ₃ O ₈ , per lb. of U ₃ O ₈	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	—
Monazite, per unit of ThO ₂	unit	42.00	—	—

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	2.15	—	—
Angles, 3 to 6-in. 1-in. thick	100 lb.	2.45	—	—
Tees, 3-in. and larger	100 lb.	2.45	—	—
Plates	100 lb.	2.65	—	—
Rivets, structural, 1-in. and larger	100 lb.	4.20	—	—
Rivets, conehead for boilers, 1-in. and larger	100 lb.	4.30	—	—
Sheets, No. 28 black	100 lb.	4.85	—	—
Sheets, No. 10 blue annealed	100 lb.	4.00	—	—
Sheets, No. 28 galvanized	100 lb.	6.20	—	—

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c. all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

GADSDEN—The Lehigh Portland Cement Co., Allentown, Pa., will build 2 large mills near here, one at Legarde and the other at Read's Mill. Estimated cost, \$5,000,000.

California

OAKLAND—The Palmolive Co., 42 3th St., Milwaukee, Wis., plans to build a soap factory, here. Estimated cost, \$400,000.

PASADENA—The Throop College of Technology will receive bids until March 10 for the construction of a laboratory. Estimated cost, \$150,000. B. Goodhue, 2 West 47th St., New York City, archt. and engr. Noted Feb. 4.

Connecticut

DANBURY—The Danbury Roller Bearing Co., c/o Sunderland & Watson, archts., 248 Main St., has awarded the contract for the construction of a 2-story, 55x85-ft. manufacturing plant, to L. F. Sweeney, Montgomery St. Estimated cost, \$25,000.

HARTFORD—The City School Bd. plans to build a 3-story high school on Maple Ave. and Benton St. Physical and chemical laboratories will be installed in same. Estimated cost, \$1,250,000. Whiton & McMahon, 36 Pearl St., archts.

MERIDEN—The International Silver Co., 48 State St., has awarded the contract for the construction of a 1-story, 42x130-ft. manufacturing plant on Brooks St., to J. H. Grozier Co., 756 Main St., Hartford. Estimated cost, \$25,000.

PLAINVILLE—The Standard Steel & Roller Bearing Co. is having preliminary plans prepared for the construction of a 1-story factory at the present factory site. Estimated cost, \$75,000.

WINDSOR—The General Electric Co., Lynn, Mass., has awarded the contract for the construction of a 3-story, 60x200-ft. factory on its plant here, to W. M. Bailey Co., 88 Broad St., Boston, Mass. Estimated cost, \$80,000.

Georgia

ATLANTA—The Corrugated Paper Products, Inc., has awarded the contract for the construction of a 2-story, 150x185-ft. factory on Stephens St., to the Massell Constr. Co., 305 Healy Bldg. Estimated cost, \$60,000.

Idaho

ASHTON—The village will receive bids until March 23 for the construction of a sewage disposal plant, etc. Estimated cost, \$120,000. Cotton & Wilson, Post Bldg., Idaho Falls, engr.

Illinois

CHICAGO—The Koppers Co. is building a plant consisting of 100 byproduct ovens and a 20,000,000 cu.ft. water gas plant for supplying gas to the city mains on the drainage canal near the city limits.

CHICAGO—The Matchless Metal Polish Co., 840 West 49th Pl., will soon award the contract for the construction of a 2-story, 100x125-ft. factory on 49th Pl. and Halsted St. Estimated cost, \$75,000. A. G. Lund, 453 West 63rd St., archt.

Indiana

EVANSVILLE—The Liquid Carbonic Co., Heidelberg Ave. and Indiana St., is having plans prepared for the construction of a 2-story, 80 x 150 ft. factory. Estimated cost, \$50,000. Clifford Shapbell & Co., archts.

Kansas

BLUE MOUND—Meese & Co. plans to move its old mill from St. Louis, Okla.,

here, and is in the market for rock drills, rolls and tables. George Meese, supt.

Louisiana

MANSFIELD—The Associated Producing & Refining Corp., Shreveport, plans to build a 5,000-bbl. refinery unit, here, ultimate capacity, 10,000 bbl. Malcolm Burns, pres.

RUSTON—The Russell Petroleum Co., of Ruston, plans to build a 1,200-bbl. refinery. Estimated cost, \$120,000.

Maryland

CURTIS BAY (Baltimore P. O.)—The Serno Corp. is having plans prepared for the construction of a plant for the manufacture of heating devices for automobiles and boats, on a 37-acre site along the waterfront, here. Estimated cost, \$1,500,000. Carl Hauer, Jr., c/o U. S. Industrial Alcohol Co., resident dir.

Massachusetts

DORCHESTER—The Mason Regulator Co., 1190 Adams St., has awarded the contract for the construction of a 2-story addition to its manufacturing plant on Adams St., to the J. T. Scully Foundation Co., 1st St., East Cambridge. Estimated cost, \$30,000.

LYNN—The General Electric Co. has awarded the contract for the construction of a 3-story, 60x100-ft. addition to its plant, to C. W. Wright, 23 Central Ave. Estimated cost, \$50,000.

Missouri

CHITWOOD—Pearl Bros. plan to remove the old Hero tailing mill and erect same on the St. Regis lease to run St. Regis tailings. The owners are in the market for 1 hoist and 2 tables.

DUENWEG—The Clear-Peach Mining Co. is building a new mill at its lead and zinc mine, here. The company is in the market for 1 compressor, 1 crusher, 2 sets rolls and 4 tables. Fletcher Clear, genl. mgr.

ST. LOUIS—The Mississippi Glass Co., 4070 North 1st St., has awarded the contract for the construction of a 1-story, 83x104-ft. glass factory at 83-91 Angelica St., to the Unit Constr. Co., Title Guarantee Bldg. Estimated cost, \$26,000.

Montana

FORSYTH—The city plans to construct a complete sewage disposal plant, etc. A \$40,000 bond issue has been voted upon for this project. W. C. Record, engr.

Nebraska

BROKEN BOW—F. M. Skillman, city clk., has awarded the contract for the construction of a sewerage system, including a disposal plant, to Smith & Chambers, Scotts Bluff. Estimated cost, \$167,000. Noted Sept. 14.

New Jersey

TRENTON—The National Porcelain Co., Southard St., plans to build a 2-story, 50x72-ft. porcelain plant. Estimated cost, \$20,000. R. G. Consolloy, 211 Commonwealth Bldg., archt.

New York

OGDENSBURG—Cooper's Brass Wks., Inc., is in the market for brass furnaces, etc. Address Robert J. Donahue.

ROCHESTER—The Virginia-Carolina Chemical Co. plans to construct a fertilizer factory on Lyell Ave. and the Barge Canal. Estimated cost, \$500,000.

North Carolina

BURLINGTON—The Mayor will soon award the contract for furnishing filter apparatus, etc., in connection with the proposed waterworks system. The Ludlow Engrs., Winston-Salem, engr.

North Dakota

COOPERSTOWN—The City Council will soon award the contract for the construction of a water softening plant in connection with the proposed waterworks improvements. Estimated cost, \$79,000. Dakota Eng. & Constr. Co., Valley City, engr.

COOPERSTOWN—The City Council will receive bids until March 8 for the installation of a septic tank, etc. Estimated cost, \$56,000. Dakota Eng. & Constr. Co., Valley City, engr.

LEEDS—The City Council will soon award the contract for the construction of a septic tank for the sewerage system. Estimated cost, \$25,000. T. R. Atkinson, Bismarck, engr.

MAYVILLE—The City Council will soon award the contract for the construction of a filtration and water softening plant. Estimated cost, \$25,000. T. R. Atkinson, Bismarck, engr. Noted Feb. 25.

Ohio

CINCINNATI—The Davis Welding Co., 1543 Queen City Ave., plans to build a factory on Borden St. Estimated cost, \$150,000.

CLEVELAND—The Cleveland Automobile Co., East 131st St., is having plans prepared for the construction of a 1-story, 80x80-ft. heat-treating plant on London Rd. Estimated cost, \$60,000. Ernest McGeorge, 1900 Euclid Ave., archt. and engr.

COLUMBUS—The Climax Rubber Co., Citizens Bank Bldg., has purchased a 7½-acre site on Northwest Blvd. and plans to construct a 3-story, 100x300-ft. rubber factory on same.

Oklahoma

ADA—The city has awarded the contract for the construction of a sewage disposal plant, to Yates & Gallamore, Ada, at \$46,936. Noted Oct. 15.

CLAREMORE—The E. B. Rankin Oil & Refining Co. plans to build a 1,500-bbl. refinery, here. Estimated cost, \$150,000. Address E. B. Rankin, Sapulpa.

PICHER—The Hunt Mining Co. is building a new 250-ton mill to replace the one recently destroyed by fire, and is in the market for new machinery. C. C. Whittier, supt.

PICHER—Moses & Marcum are moving the old Grayston mill from Tanyard Hollow to this city, and are in the market for gas engines, rolls and 6 tables. J. G. Marcum, supt.

ST. LOUIS—The Aztec Mining Co. plans to build a 250-ton mill at its lead and zinc mine, here, and is in the market for entire new equipment. Harry Larsh, supt.

TULSA—The Robinson Packer Co., 226 East 3rd St., plans to build a 2-story, 90x130-ft. factory at 209-17 North Main St., for the manufacture of oil well supplies. Estimated cost, \$100,000. O. K. Eysenbach, pres.

Pennsylvania

LEMOYNE—The Pennsylvania Concrete Tile Roofing & Cement Products Co. will build a 1-story, 40x100-ft. factory for the manufacture of cement products. Estimated cost, \$6,000. Work will be done by day labor.

PITTSBURGH—The Philadelphia Co., 435 6th Ave., has awarded the contract for the construction of a large blue gas plant near here, to the Bartlett Hayward Co., Scott and McHenry Sts., Baltimore, Md. The company has been compelled to build this plant owing to the shortage of natural gas.

West Virginia

SISTERSVILLE—The John B. Scohy Glass Co. is building a glass factory.

Ontario

NIAGARA FALLS—W. J. Seymour, City Clk., will receive bids until March 15 for furnishing a 35 gal. capacity chemical tank, etc. D. T. Black, Erie Ave., engr.

PETERBORO—The Canadian Aladdin Co., Canadian Pacific Ry. Bldg., has awarded the contract for the construction of a 3-story, 60x80-ft. factory for the manufacture of electric bulbs, etc., to the Dickie Constr. Co., Pyrie Bldg., Toronto. Estimated cost, \$125,000.

TORONTO—The Keystone Products, Ltd., 133 Eastern Ave., is in the market for 1 second-hand electric furnace, etc.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CANADIAN MINING INSTITUTE will hold its annual meeting at the King Edward Hotel, Toronto, March 8 to 10.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theatre: "Helium," Monday, March 29, at 4 p.m., Dr. R. B. Moore, chief chemist, U. S. Bureau of Mines (*Lantern*); "Romance of Leather Making," Tuesday, April 13, at 4 p.m., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonnements," Wednesday, April 21, at 4 p.m., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Fire-foam," Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Fire-foam Co. (*Experimental, cinema and lantern*).

THE FARADAY SOCIETY (London) will hold a meeting on March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institute of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning October 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE BLAW-KNOX Co., Pittsburgh, Pa., has purchased the C. D. Pruden Co. of Baltimore, Md., manufacturer of standardized steel buildings for industrial plants, warehouses, cottages and garages. The Blaw-Knox Co. also announces that J. Grier Campbell, purchasing agent of the company, has resigned to become assistant treasurer of the C. D. Pruden Co. and that W. S. Boyd, formerly assistant purchasing agent of the Crucible Steel Co. and purchasing agent of the Page Steel & Wire Co., has been appointed purchasing agent of the Blaw-Knox Co. to succeed Mr. Campbell.

THE PHILADELPHIA TEXTILE MACHINERY Co., Philadelphia, Pa., manufacturer of dry-

ing machinery, has opened an office in the East River Bank Bldg., 291 Broadway, New York, of which H. S. Landell will be in charge.

THE EASTON CAR & CONSTRUCTION Co., New York, has opened a branch office in Room 400, Penobscot Bldg., Detroit, Mich., in charge of H. H. Siff, the district sales engineer. This company announces that this branch office will carry a stock of spare parts as soon as the demand for such service makes it advisable.

THE EASTERN PRODUCTS Co., of Putnam, Conn., has been incorporated to deal in chemicals, dyes, etc. The company will start with a capital of \$25,000, and the organizers are as follows: Samuel Smith, 64 Ring St., Putnam; George F. Bidwell and G. A. Bidwell, both of Putnam, Conn. Address all matters to Samuel Smith, president.

THE NATIONAL CHEMICAL PRODUCTS Co., of 59 Elm street, Stamford, Conn., has been organized to make and deal in chemicals, etc. The officers of the new company are as follows: Philip Sedwosh, president; B. Troupin, vice-president; Eli S. Troupin, secretary and treasurer. Mr. Sedwosh is an experienced chemical man, and both B. Troupin and Eli S. Troupin are in the drug business in Stamford. The new company is now in operation.

THE MAHER ENGINEERING Co. of 30 North Michigan Ave., Chicago, announces the opening of a branch office under the direction of Lincoln E. Maher at 708 Scofield Bldg., Cleveland, Ohio. This office will distribute Erie Engine Works engines, Dayton-Dowd Co. centrifugal pumps and Galand-Henning hydraulic presses.

THE INTERNATIONAL ACETYLENE ASSOCIATION is making a census of schools where the art of oxy-acetylene welding is taught. The purpose of this census is to assist the association in answering inquiries from persons desiring to secure competent artisans in this kind of work. A blank form will be sent to any institution desiring to be registered with the association.

FREYN, BRASSERT & Co., Peoples Gas Bldg., Chicago, has made arrangements with the Gellert Engineering Co. of Philadelphia, Pa., for the mutual handling of Cottrell electrical blast-furnace gas cleaners for the entire world. Freyn, Brassert & Co. will have exclusive charge of sales and will co-operate with the Gellert Engineering Co. which is the exclusive builder of the Cottrell cleaner in the United States in the installation and practical adaptation of this apparatus to the particular requirements of blast-furnace practice.

Creditors of the METALS PRODUCTION EQUIPMENT Co. (bankrupt), Springfield, Mass., are notified that a second dividend of 10 per cent has been declared on all claims which have been proved and allowed but not entitled to priority. The trustee has been ordered to pay in full all claims which have been approved and allowed and are entitled to priority. The dividend is payable by Trustee Harry C. Dodge, Boston, Mass.

SIR RALPH FORSTER, Bart., has given £34,500 to the fund for building and equipping the chemical laboratory of University College, London. The department of organic chemistry will be called the Forster Laboratory.

Manufacturers' Catalogs

THE HAUCK MANUFACTURING Co., Brooklyn, N. Y., has issued a new bulletin, No. 119, illustrating and describing in detail its different types of oil burners. The catalog contains results of tests which are of particular value.

THE WELLMAN-SEEVER-MORGAN Co., Cleveland, Ohio, has just issued Bull. No. 49, giving views of a number of types of car dumpers together with blue prints of these machines. Copies will be sent upon request to any one interested.

PYROELECTRIC INSTRUMENT Co., Trenton, N. J., is issuing its January, 1920, bulletin, No. 10, the subject of which is "Secondary Standards of Inductance," by E. F. Northrup. This bulletin formerly came out once a month but now comes out bi-monthly, starting with this issue.

ELECTRO BLEACHING GAS Co., Niagara Falls, N. Y., announces a new publication entitled "Liquid Chlorine," which contains illustrations and descriptive matter.

N. B. PAYNE & Co., New York City, has just issued a new bulletin entitled "Lane Electric Cranes." This company is the sole agent for Lane electric cranes, manufactured in Montpelier, Vt., by the Lane

Mfg. Co. The bulletin fully illustrates and describes several styles of cranes in which steel girders or heavy timbers of long leaf yellow pine are used. It contains a complete set of specifications and a list of users. A questionnaire is inserted in the bulletin for the use of the prospective purchaser on which can be written all information needed by the manufacturers. A free copy will be mailed upon request.

THE AMERICAN PULVERIZER Co., East St. Louis, Ill., announces Cat. No. 53 on the pulverizer that solves your problem. Illustrations and descriptive matter are given, including the standard pulverizers, coal crushers, shredder and disintegrator, and chemical machines.

THE ELECTRIC FURNACE Co., Alliance, Ohio, is distributing Booklet 8-B, entitled "Some Installations of Bailly Electric Furnaces," melting non-ferrous metals. This booklet is profusely illustrated, with some descriptive matter, together with a list of the sizes built.

WESTINGHOUSE, CHURCH, KERR & Co., INC., New York, has issued a leaflet entitled "W. C. K. City." A large photograph is given showing many buildings erected by this company, which include manufacturing plants, shops, foundries, power plants, railroad terminals, hotels, etc., together with descriptive matter.

THE DELAVAL SEPARATOR Co., New York, has published Bull. No. 200, on the DeLaval method of centrifugal clarification of varnishes, japans and pigment goods, illustrating and describing multiple clarifiers, centrifugal filters, belt-driven machines, also the mechanical construction of the centrifugal machines, how the multiple clarifier bowl works and how the centrifugal filter bowl works.

THE KOPPERS Co., Pittsburgh, Pa., has issued a booklet on "Coal and Byproducts."

THE NORTHERN EQUIPMENT Co., Erie, Pa., calls attention to a 24-page booklet, entitled "Saving Fuel Automatically and Scientifically in the Boiler Room," based upon matter that was prepared for the United States Fuel Administration during the war. In the preface of the booklet the manufacturers say: "When the war ended we thought we had done our duty, and that the fuel situation would ease up a bit. However, we find the fuel problem now becoming serious. Prices will not come down because wages will evidently stay up or will go higher." The booklet compares hand and mechanical feeding with mechanical regulation, as performed by the Copes Regulator. It shows what is to be desired in the way of scientific boiler feed regulation. Many charts and diagrams are shown to emphasize the value of scientific control, together with a list of the users of Copes Regulators.

THE MEAD-MORRISON MFG. Co., East Boston, Mass., has issued a very attractive catalog, No. 21, on hoisting machinery. The catalog contains 166 pages illustrating and describing the different types of hoisting machinery for coal, ash and ore handling machinery, steam hoists, electric hoists, belt and gasoline hoists and grab buckets.

PORTABLE MACHINERY Co., INC., Passaic, N. J.: A bulletin has just been issued on portable belt conveyors for handling material horizontally or at a slight incline which are described and illustrated. It contains prices of these machines which are made with 16-in. wide belt and in standard stock sizes as follows: 12 ft. 6 in.; 16 ft.; 19 ft. 6 in.; 23 ft.; 26 ft. 6 in.; 30 ft.; 33 ft. 6 in., and 37 ft. These machines in addition to being used for handling coal, sand, crushed stone, fertilizer, etc., can be used for conveying many manufactured products, bagged material such as cement, etc.

THE INDUSTRIAL GLOVES CORP., Chicago, Ill., is issuing a booklet on industrial gloves and mittens. Illustrations and descriptive matter are given on gloves, mittens, arm protectors, hand pads, leggings and aprons, together with the prices.

THE GRISCOM-RUSSELL Co., New York, desires to announce Bull. No. 231, on the G-R instantaneous heater.

THE INDUSTRIAL PRODUCTS Co., Mutual Life Bldg., Philadelphia, has published a folder illustrating and describing industrial acid hoods and suits. These are products of acid-proof rubberized cloth designed to protect those who have to deal with acid lines, storage tanks and processes in which acids are used.

W. S. ROCKWELL Co., New York City, has issued Bull. 208, "The Function of Oil Burners in the Operation of Furnaces." This bulletin is being distributed with the idea of correcting the erroneous impression held by some regarding the real function of oil burners in the operation of furnaces.